computing today

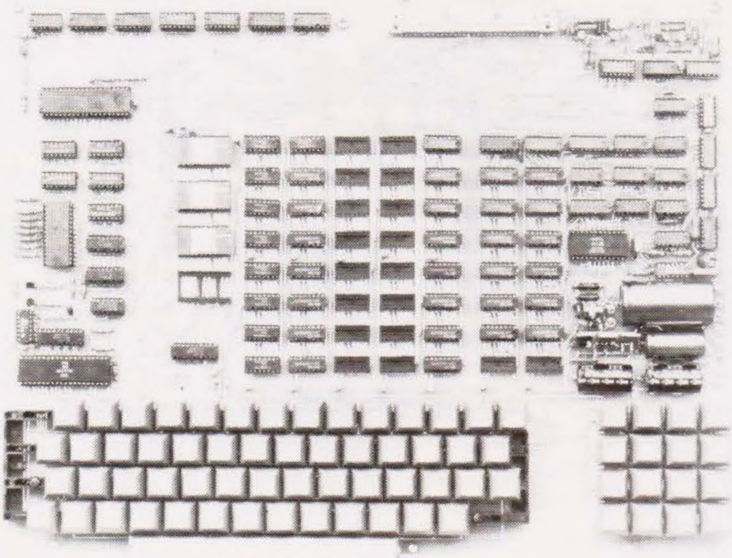
ISSN 0142-7210
JUL 1979
50p

GETTING INTIMATE WITH SUPERBOARD
IN DEPTH REVIEW

MPUs BY EXPERIMENT

CLUB SURVEY

ψ COMP 80
POWERTRAN
ψ COMP 80



computing today

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JULY '79

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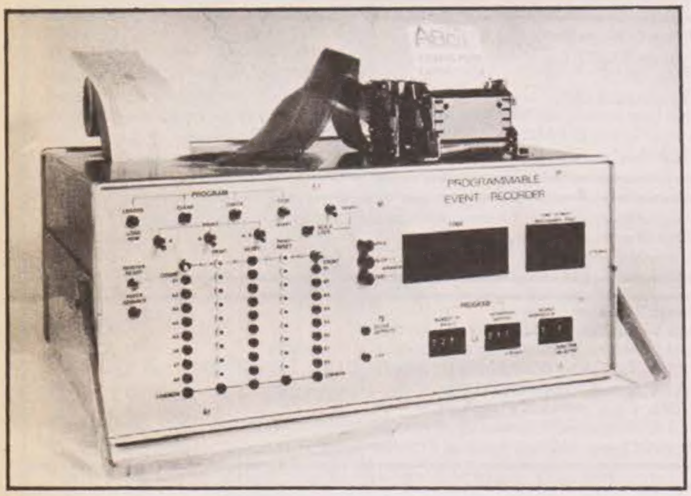
PRINTER FOR EVENTS

The silent printer mechanism from Dataplus that we mentioned in last month's news is being built into a programmable event recorder.

The model 4001 is produced by Kinson Electronics of London and is a 16 channel machine. It is being used to record the results of experiments on animals by the Life Sciences Laboratory. The printer was chosen for the application because it can operate at high speed, up to 400 cps. silently and thus not disturb the animals under observation. Dataplus are on 0242-30030.

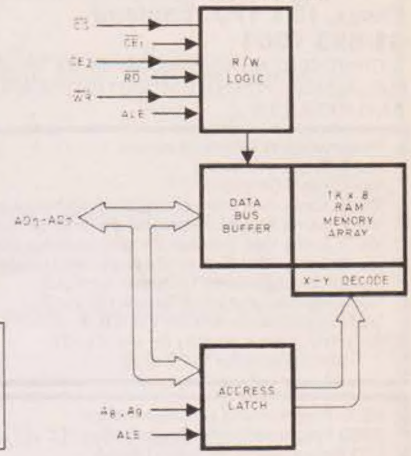


PIN CONFIGURATION

PIN NAMES

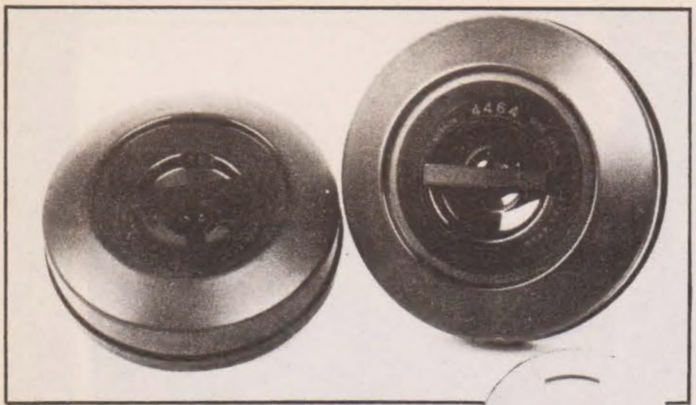
AD_0-AD_7	ADDRESS/DATA LINES
A_8, A_9	ADDRESS LINES
$\overline{CS}$	CHIP SELECT
$\overline{CE_1}$	CHIP ENABLE (IO/$\overline{M}$)
CE_2	CHIP ENABLE
ALE	ADDRESS LATCH ENABLE
$\overline{RD}$	READ ENABLE
$\overline{WR}$	WRITE ENABLE

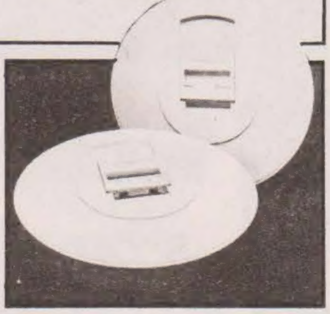
BLOCK DIAGRAM



RAM AN 8085A!

Rapid Recall's offering for the month is a 1K by 8 Static RAM for the 8085A CPU. Called the 8185 it is directly interfaceable to the multiplexed bus. Two speeds are available to suit either a standard 8085 or the faster 8085A–2. The device uses a single 5V rail and operates in low current mode when not selected, thus reducing power consumption. Rapid Recall are on 062-85-24961.





GNASH YOU A DISK

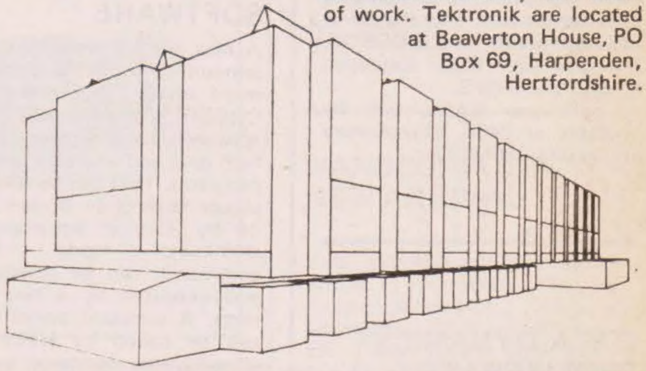
Two new disks are available from Nashua. The SMD series offer capacities from 40 to 300 MB and can be supplied pre-formatted to suit a range of drives. All disks are certified before shipping and production standards meet or exceed all industry standards. The second disk is for top pack loading systems and is designated Model 4442. A 10MB version is available for the Data General 6070 drive and a 12.5MB version for the Wangco ST2422 for Datapoint 9374 drives. More details from Nashua Corporation, Computer Products Division, Cory House, Bracknell, Berkshire.

PROGRAMS AT 20P

Petsoft are offering 76 of their most popular financial and maths programs in a package for £15 incl. VAT, less than 20p a program. Developed by Adam Osborne many have appeared in his book, "Some Common Basic Programs" and all have been modified for the PET. Available at local dealers or mail order they will also soon be available on disk. The book is also available at £7.50. Petsoft are at 5–6 Vicarage Road, Edgbaston, B'ham B15 3ES.

TEK GRAPHICS BUILD

Using Tektronik 4010 graphics terminals the Strathclyde University Architecture and Building Aids computer system ABACUS is helping to promote the use of computers in the building trades. By using systems such as the ones developed at the university an architect can make changes to a design simply and quickly without resorting to traditional methods. Programs allow for analysis of heat losses, elevator systems and many other common requirements that would normally take hours of work. Tektronik are located at Beaverton House, PO Box 69, Harpenden, Hertfordshire.



MORE APPLES FOR US

Keen Computers of Nottingham are importing the Apple II into the UK after talks with the American parent company. They also hope to organize a dealership network in the UK for the machine in order to provide better support and service facilities than have previously been available. Software development for the machine is also to be expected. For more information contact Keen on 0602–583254.

COBOL RULES OK

Micro Focus's CIS COBOL has been chosen by two firms to run on their machines. Computer Mart of Norwich are using it for data processing applications based on the Imsai microcomputer. North Star have also chosen it to run on their Shugart based disk systems with the Lifeboat Associates version of CP/M.

Supplied on two mini-floppies CIS COBOL is a subset of the ANSII standard COBOL and can operate in 32K of RAM. More information from Micro Focus at 58 Acacia Road, St. Johns Wood, London NW8 6AG.

FINTERM FROM TALLY

An intelligent printer terminal for financial applications is to be introduced by Tally of Reading. The M79 is designed for use in banks, building societies and other financial institutions for printing on a variety of media. Capable of handling passbooks, single sheets or reel-fed stationery it can print at up to 200 CPS with a seven high 207 matrix head. An optical search facility allows it to add lines to a previously printed document in the right place. Produced in Germany by Tally's sister company it will be available in the UK from October, demonstration models are available now. Contact Tally on 0734-580141.

SCOTS FIRST WITH HARD DISK

The Edinburgh based MicroCentre computer shop is the first in the country to have the new Cromenco Z–2H micro with an integral 11MB hard disk. Costing £5748 it uses the 4 MHz Z80A CPU, with twin floppies, single hard disk and 64K of RAM. Housed in a table top cabinet it was first shown at the West Coast Computer Faire in May.

All systems supplied by MicroCentre will be maintained by CFM under a special arrangement. Software is available at £65 per package and the range includes ANSII level 1 COBOL, Fortran IV, 16K Extended BASIC, and a WPS.

A multi-user BASIC will be available at £460. MicroCentre are on 031-225-2022.

DATA/DYNAMICS PROLIFERATE

Items of news from Data Dynamics this month.

They have just reduced the price of their WP system, the Artec International Display 2000 from £6950 to £5500. Comprising two units, a free-standing floppy disk and a printer/keyboard, the unit features a unique display system. Rather than using a VDU it has a single line plasma display that should prove both easier to read and reduce eyestrain. The second item is a new leaflet on their 5 level keyboard printer, the ZIP-ASR. Designed for use on private Telex networks the machine can be used to produce tapes off-line. For further material on these products contact Data Dynamics at Data House, Springfield Road, Hayes, Middx.

2020 IN THE SHADE

MicroSHADE of Calne are extending their range to stock the ITT2020 the licenced version of Apple. Supplies of this machine are hoped to relieve the delivery problems of Apples and also to boost the aftersales support. MicroSHADE are acting as agents for Telefusion, the wholesale distributors of the machine for the West Country, Norfolk and the North East. Shade live at 1 Patford Street, Calne, Wiltshire.

NEW INTEL SOFTWARE

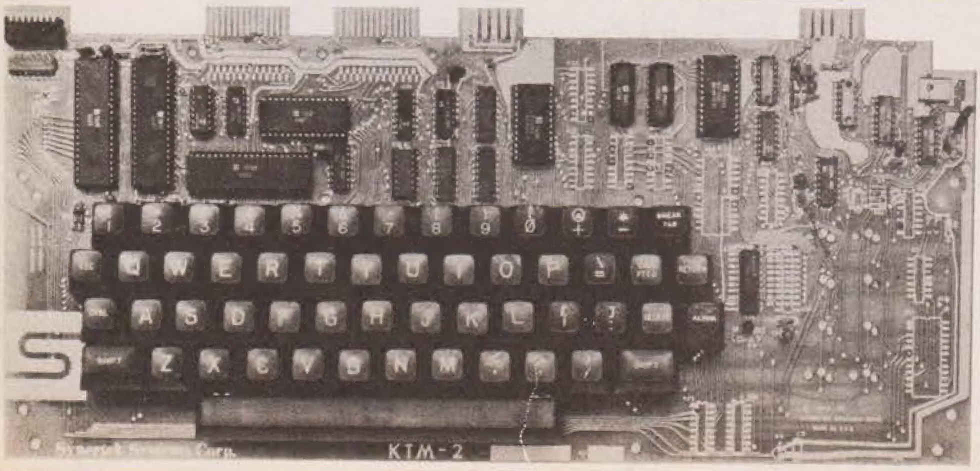
A new editing system has been announced for Intellec development systems by Intel. Called CREDIT it allows a WP approach to the generation of high level and assembly language programs. Text can be edited by cursor control in Screen mode or by specific commands in Command mode. Macro commands can be constructed and executed by a two letter code. A constant option chart can be called by HELP thus allowing easy operation by anyone. Intel are at 4 Between Towns Road, Cowley, Oxford OX4 3NB.

UP A MYTH?

After much recent press comment on word processor systems the Managing Director of Abacus, Derek Rowe, has had a go at dispelling some of the mysticism. In a talk to sales staff he pointed out that a WP system is just that, it doesn't solve all the customers problems overnight. However, if you sell that client a computer with a WP package he can use it for other things as well, such as accounting. A most reasonable view, and one which may well help many business people to take a second look at the "miracle machines".

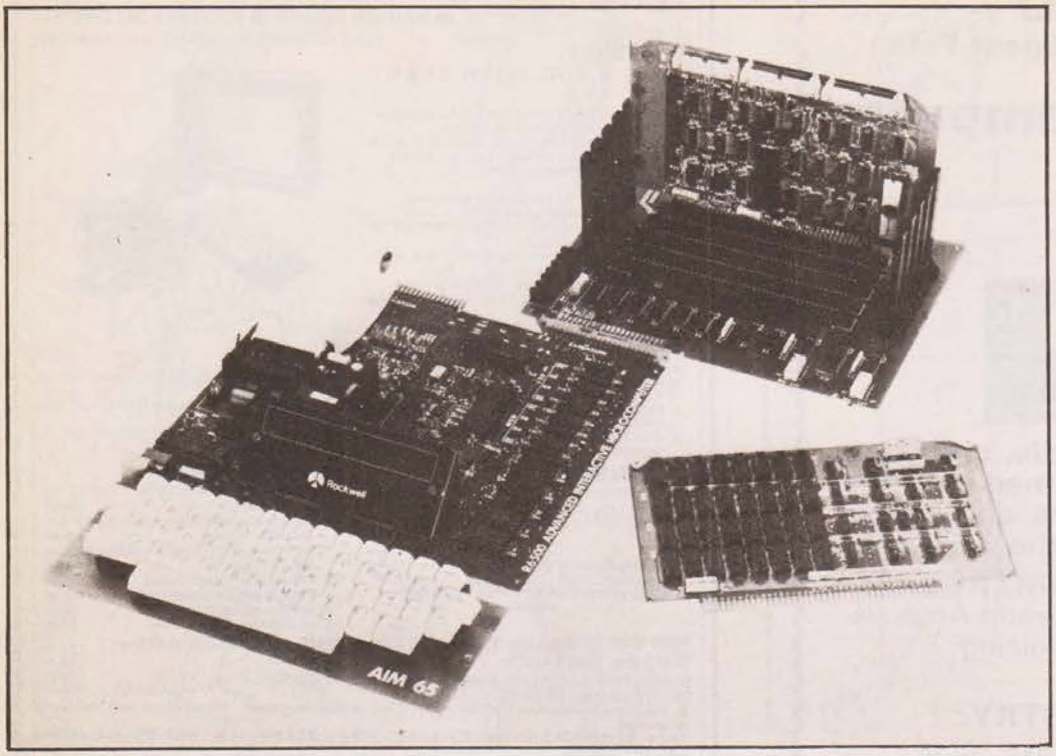
JAP MICROS ARRIVE

The range of SORD microcomputers from Japan are now available in the UK. Costing between £1000 and £4000 they use the 280 CPU and have all the usual peripheral options including floppies, printers etc. They appear to be S100 based and the photo shows the top of the range M223 with its integral 1.4MB of disk store, RS232 port and a wide range of software including CAP Microproducts range. For more information the main distributor, Dectrade Ltd, may be contacted at 11 Musters Road, West Bridgford Nottingham or on 0602-861774.



NEW KEYBOARD

Rastra Electronics of Hammersmith are now supplying the new Synertek KTM–2 keyboard module.Providing the full ASCII set on a 24 by 40 matrix it gives a low-cost, high-performance display terminal capability.With the built in relative and absolute cursor addressing modes it is possible to produce animated graphics easily.The whole unit runs off a single 5V rail and is directly connectable to a video monitor. A modulator can be fitted to drive a standard TV. Further details of this and the rest of the SYM range from Rastra at 275-281 King Street, Hammersmith,London W6 9NF.



MICRO COURSES

Portsmouth Poly's Electrical and Electronic Engineering Section are running some courses for engineers who wish to get experience on micros. The first course is a three day introductory session and runs 4–6 June, 26–28 September and 3–5 December, fee is £85 inclusive. The second course is a follow up, again a three day course, and runs 9–11 July and 5–7 November, fee is £90. Both include hands-on experience. More advanced courses are planned and anyone who is interested should contacts Mrs A.P. Sizer at the Poly, Anglesea Bldg., Anglesea Rd., Portsmouth PO1 3DJ or ring 0705-27681.

NANOCOMPUTER IS NEW ARRIVAL

This morning we had a new arrival in the office. The first production unit of a Z80 based educational and development kit. Produced by SGS-Ates it has 4K of RAM and 2K PROM on board with twin parallel ports and a single serial port. Using the basic hand held terminal it forms an educational and training system at £203. Upgrading is easily performed and card frames, experimental kits, power supplies etc. are soon to be available. We have a unit at the moment and will produce a test report in the next issue.

TEXAS ARRIVES

It's here at last and we can tell you all about it! No real surprises unfortunately, the system was launched on Sunday in Chicago after a Press announcement on Friday 1st June. Comprising 16K RAM, sound generator, full colour graphics and extended BASIC the system is called TI-99/4 and can drive any colour or black and white monitor or NTSC TV. Hopefully a PAL version will be available for the UK. Using plug-in solid state software modules containing up to five ROM's a range of software has been announced to coincide with the machine and the first batch includes Household Management and Budget, Football, Videographs, Demos and Diagnostics, Beginning Grammar and a few more. Future add-ons will be a printer, disk, RS232 interface, and a Solid State speech synthesiser. The synthesiser will use the same chip as the Speak and Spell machine and have a 200 word vocabulary. The BASIC is full floating point, 13 digits and is compatible with the ANSII specification. It has 24 statements, 14 commands, 16 colour graphics and four octaves of music. A BASIC guide and reference manual are supplied. UK Software modules will include Pre-school learning, Video Chess and Home Budgeting. The machine will be here in the fourth quarter and will sell for £645, Software costing £15 to £50 per module.

AIM TO BUBBLE

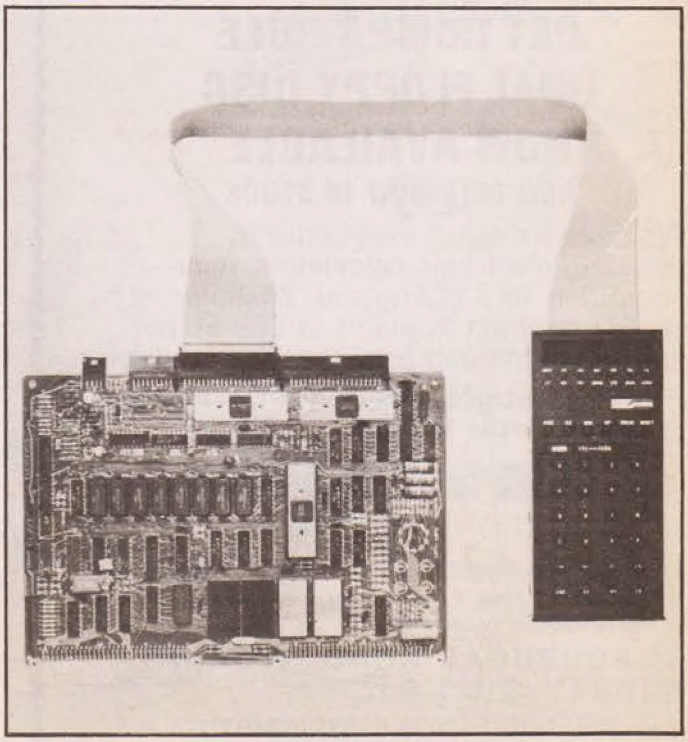
The AIM65 can now be equipped with a fully addressable 1 MB bubble memory. Using the new expansion motherboard available from Pelco at £136.50 you can add — on to your system to produce smart terminals or desk top computer.

A variety of modules are available to plug in, from the Rockwell system 65 to Motorola Exorciser, as well as some from Burr-Brown. The bufferboard is scheduled for June and pricing for the add-on boards including the bubble memory are available from Pelco at Enterprise House, 83–85 Western Road, Hove, Sussex BN3 1JB.

MICRO-BASED TRANSLATOR WITH HONG KONG LINK

A Hong Kong firm, working in conjunction with an American designer and a San Francisco software House and producing hand held translator units. Housed in a calculator style package the unit contains eleven IC's, 32K of RAM and a 32K plug-in ROM.

At a cost of $200 in the States the firm is producing about 1000 a day at the moment, languages currently available are English, and a choice of French, German, Spanish, Portuguese, Italian or Japanese. Apart from acting as a language translator the unit can be used as an educational tool, future models are expected to contain such diverse information as recipes and Olympic records. For further data contact the Hong Kong Trade Development Council at 14-10 Cockspur St, London SW1Y 5DP



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FLETCH

"I've invented silicone chips capable of controlling nuclear fission".

"You mean . . . ."

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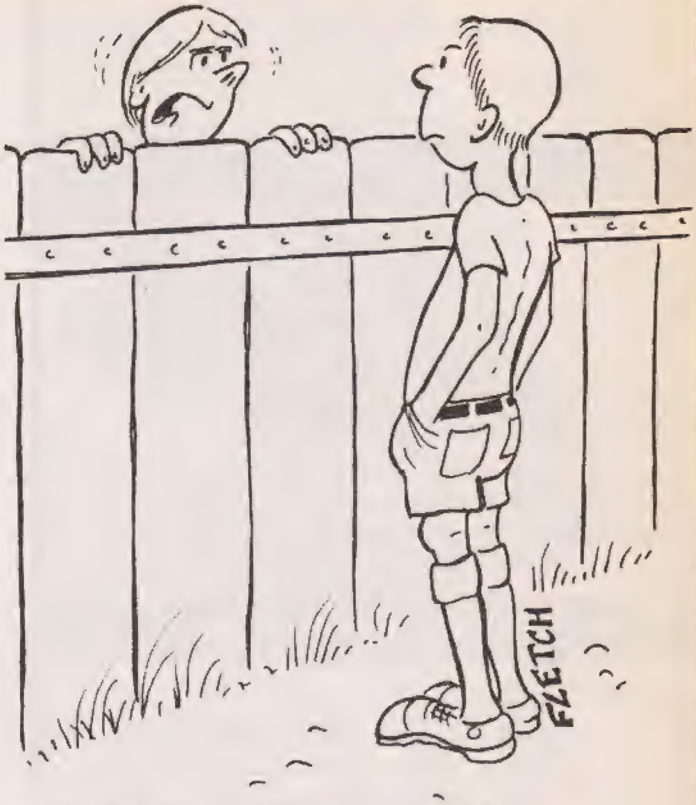


"An' what's more—my dad's home computer is bigger than your dad's !"

"I'd like to exchange it—my wife doesn't like the colour."

MPU's BY EXPERIMENT

Ian Sinclair starts off his new series on the workings of microprocessors

One of the problems of getting heavily involved in the software aspect of microprocessing is that you tend to lose sight of the hardware which makes it all possible. Most of all, you tend not to learn enough about the microprocessor itself, which is rather a pity. The microprocessor has made the home computer possible, but its impact in other directions is going to be a lot more important; we shouldn't forget that home computing was (and still is!) the last application that the designers of most microprocessor (CPU) chips had in mind.

The aim of this series, therefore, is to find out what goes on in this important chunk of silicon. To do this, we've devised a bit of practical work which will guide you, with minimum cost, to a much better understanding of just one type of microprocessor. Just one, because time and money make it impossible to go through the action of all the major CPU chips which are on offer at the moment. The chip we've chosen to put in the pan is the familiar SC/MP by National Semiconductor, now referred to as the INS8060. The reasons for choosing this one are:

1. Easy availability — there's not much point in using a CPU which is available only to the trade, or at a high price.
2. A single voltage power supply. The modern INS8060 uses a single 5 V supply, and takes a modest current. The earlier SC/MP used dual +5 V and −7 V supplies, and is not suitable for this application.
3. A simple instruction set. The INS8060 is designed for machine control rather than for computing, so that its instruction set is reasonably short and simple.
4. A lot of useful facilities on one chip. By using the 8060, we've been able to keep the number of support chips, hence the cost, down to a minimum.

The Bare Essentials

At the starting level, we shall be working with the bare microprocessor and three small support chips, plus a lot of toggle switches and LEDs on a low-cost breadboard, the Eurobreadboard. This enables you to find out exactly what happens at each instruction, because this elementary layout has been designed so that the result of each clock pulse, and some of the actions between each clock pulse, can be examined. A major factor in choosing the Eurobreadboard format, incidentally, is that it can be used for other chips as well, unlike a PCB layout.

Once we've gone through the instruction set in detail, we shall need to look at how these instructions are used, and this brings us to the second phase of the work. For this we need more equipment, a hexadecimal keyboard and readout, RAM memory, and a monitor program to make it all go. The easiest and cheapest way of buying this lot is as the Science of Cambridge MK14, and that's what we'll use. Now if you're interested only in the basic microprocessor work and don't intend to buy the MK14, the buy-list for this particular section of the program is as shown. If you intend to stay with it to the bitter end, or have your own MK14 already, then you can use the SC/MP chip from the MK14 (provided that it is the modern, single-voltage supply type), so saving £8.50 or so on another INS8060. You may, of course, feel that you can use another 8060.

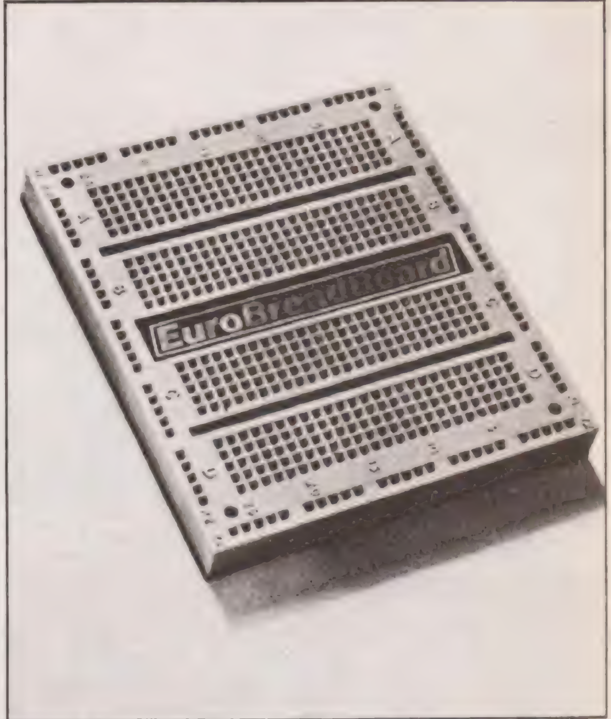


Fig. 1. The Eurobreadboard which forms the basis of the microprocessor assessment unit. Note the numbering and lettering which lets us identify each row of contacts in the table of connections.

Let's start in right away with the bits of the breadboard system. The Eurobreadboard is conveniently shaped for this sort of work, and the latest versions have the rows of contacts numbered, and the columns lettered so that we can show the layout without needing to use too many drawings. Fitting the 40-pin CPU into any socket can sometimes be a bit of a struggle, and it's sometimes an advantage to open the spring contacts of the Eurobreadboard a bit rather than risk bending pins on the 8060. My own Eurobreadboard accepted the 8060 very easily, with just a gentle push needed to bed the chip right home. Remember that the 8060 is a NMOS chip, which means that it *is* possible to damage it by static from your fingers. Don't therefore try to place the 8060 on the board until all the connections are made and the rest of the circuits tested, and don't try to poke a pin into place by hand. Keep the 8060 in its protective packing until the last possible moment, and once it's in place on the board, leave it there.

Two of the other chips we've used are 74LS126's, which are the low-power TTL chips so readily available now. These can be put onto the board right away, positioning and wiring + and − connections as shown in Fig. 2. The remaining chip is a 74LS132, a quad Schmitt Nand gate, which is used for buffering and as a clock oscillator.

The remaining board wiring can now be completed, as shown also in Fig. 2 leaving only the off-board wiring, power supply connections, and the INS8060 to deal with. Of that, more later; first a word about basics.

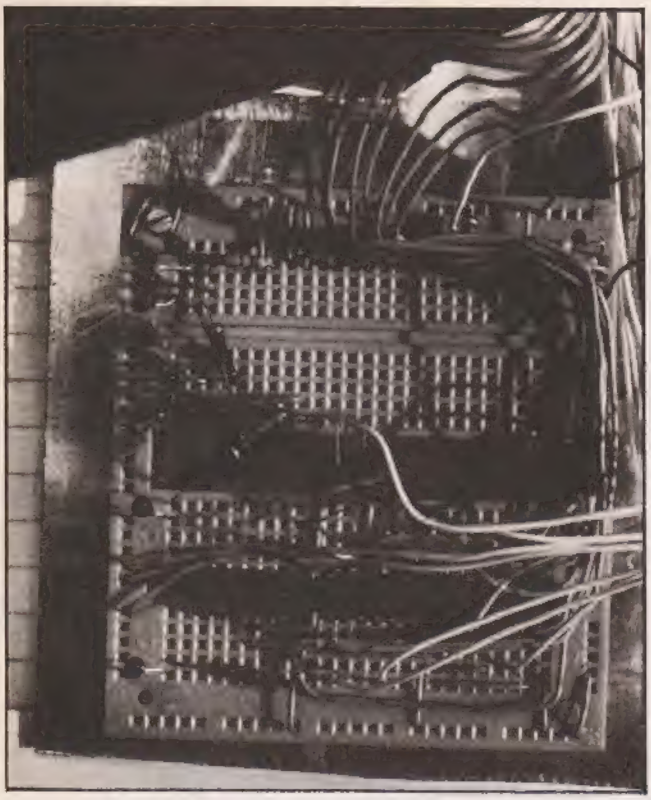


Fig. 2. The TTL chips in place, and the board wiring ready for the first few experiments. some circuit changes (shown on other photos) are made later, as detailed in the text (Part 3 onwards.)

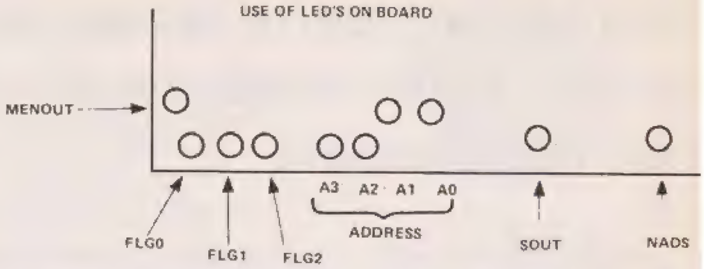


Fig. 3. How the on-board LEDs are used. A few extra LEDs are also used for odd items, later.

What It Does

The circuit operates like this. One of the gates of the 74LS132 is used as a clock pulse generator, whose frequency can be altered by changing the capacitor marked C*. This clock pulse is put into the 8060 at its "clock in" (XIN) pin, which is pin number 37 on the big chip. I had originally hoped to use the push-button for clocking really slowly, but this caused rather erratic behaviour inside the 8060, of which more later. The push-button switch in this version now operates the input marked NHOLD, on pin number 6, whose function is to suspend operations just at the point when the microprocessor gates its data inputs to the switches that are connected to the 74LS126 buffers.

These eight data switches can be set to logic 1 (toggle pointing upwards in the prototype) or zero. We can't connect these switches directly to the data pins of the 8060, because the data pins of the 8060, in common with most other micros, are used for feeding signals in or out, and if we were trying to put data in at the same time as the microprocessor was trying to put data out, the microprocessor would lose the contest — and that's expensive. The data switch outputs therefore go to the inputs of the 74LS126 buffers, and the outputs of the buffers go to the data pins. These buffer circuits are three-state, meaning that there's a connection to their output pins only when the enable pins are at the correct voltage, high in the case of the 74LS126. That way, the voltages from the toggle switches are connected into the data pins only when the enable pins of the buffers are high. What switches the enable pins high? As we'll see, this is done by a pulse from the microprocessor itself, the output labelled NRDS from pin 2. There is one enable pin for each buffer, a total of eight, and because eight enable inputs, even of these lower-power chips, are a bit much for the 8060 to drive, and because the NRDS signal is a negative-going pulse, one gate of the 74LS132 is used as an inverter and buffer.

One of the two remaining toggle switches is used for resetting the microprocessor, using pin 7. The voltage on this pin, labelled NRST has to be high (+5 V) for normal running, low to reset, and a simple toggle switch carries this action out in our circuit. The other toggle switch will be used to simulate a serial input, such as might be obtained from a cassette recorder.

The LEDs are used to indicate outputs. The eight LEDs which are mounted above the data toggle switches are operated from the data pins of the microprocessor, and will indicate either when data signals are being read in, in which case the LEDs will indicate the number to which the toggle switches are set, or when data is being written out from the microprocessor. In this second case, the number which is being written out need not agree with the number to which the toggle switches are set.

The other important group of LEDs are connected to four of the address pins, A0 to A3 inclusive. These LEDs are set in a row so as to indicate a binary number, the number of the address in memory which the INS 8060 is trying to address. We don't have any memory chips — as you'll see, you're the memory!

The other LEDs are used to indicate what the microprocessor is doing. One is connected to pin 4, labelled NENOUT, and indicates one particular stage in the processing of an instruction. Three more LEDs are used to indicate the stage of 'flags', outputs which can be programmed in any way the user wants (one of the features, incidentally, which makes the 8060 such a useful control device). The other two LEDs are used to indicate the state of pins 39 and 23. Pin 39, labelled NADS is another indicator of a stage in processing an instruction; pin 23, labelled SOUT is an output for bit-by-bit serial data.

Construction Details

Meanwhile, on with the construction. The circuit diagram is shown in Fig. 4. IC4a is used as the clock pulse generator, whose frequency is set by the value of C*. This value is 250 uF for the first few experiments, but a 25 uF capacitor is used later, so that this capacitor should be accessible and not buried under lots of wiring — this is just one of the many reasons for using a breadboard. There will also be an additional capacitor and resistor to plug in later. Only three of the NAND gates of the 74LS132 are used initially.

The push-button has a 0.1 uF capacitor wired across its contacts to help eliminate switch bounce problems, and is connected to IC4b, another of the 74LS132 gates. The out-

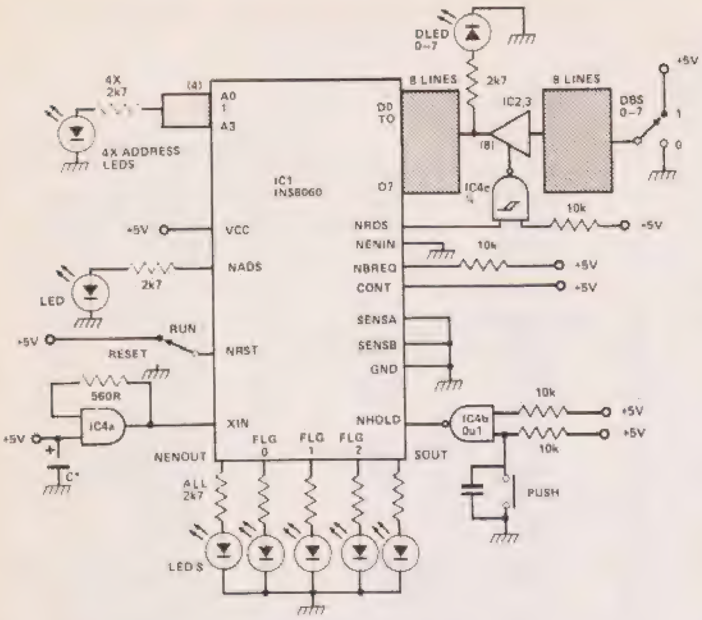


Fig. 4. The circuit diagram — where several identical circuits exist (as on the address and data lines) only one is shown.

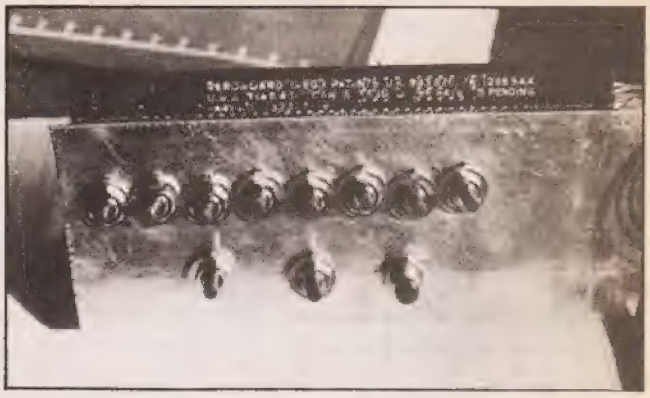


Fig. 5. The control panel. The row of eight toggle switches are for data entry, with D7 at the left and D0 at the right. The LED indicators are mounted above the switches. The bottom row is (from left to right), SIN, RESET, PUSH.

put of this operates the 8060 NHOLD input. With this input (on pin 6) low, the microprocessor stops just at the stage when data is to be fed in or out. When this pin is switched high, operations continue normally after a short delay. This way, we can examine what is happening one stage at a time.

Various outputs of the 8060, including the four lowest order address lines, are taken through 2k7 limiting resistors to LEDs, so that the logic voltages can be read as 1 (glowing) or 0. LEDs are also used on the data lines, but are separately mounted along with the data switches. For the prototype, which was as untidy as a rat's nest as you are ever likely to meet, I used an aluminium panel, earthed to the Eurobreadboard negative line, on which the toggle data switches were mounted as shown in Fig. 4. Two more toggle switches (reset and serial input) were mounted in a row underneath along with a push-button switch which is used as the GO switch. A set of eight LEDs is strung on to a Veroboard strip, as also shown in Fig. 5 and Fig. 6 along with limiting resistors of 2k7, and the strip is secured to the panel with double-sided Sellotape (all high-technology stuff, you'll note, even if I did cut out the panel with my teeth). Switches and LEDs can then be labelled, starting with 7 for the left-hand side and going down to 0 for the right-hand side. These numbers correspond to the numbering of the data pins of the 8060. I must confess I didn't number the switches or LEDs on the prototype — by that time I knew where everything was.

Another ten LEDs are mounted on the Eurobreadboard itself, as listed in the connections table. These LEDs are used to show what voltages exist on the 8060 output lines, including four of the address lines. Four address lines permit sixteen program addresses to be displayed, and when you find out what is involved in each step of program you'll stop saying 'only sixteen' so loudly.

Wiring Up

A 2k7 current-limiting resistor has been used for each LED, and various 10k pull-up resistors have been connected at inputs. Once again, the connections list shows what is connected to each socket row of the Eurobreadboard — another advantage notched up. The TTL ICs can be inserted first, since they will not come to any harm during wiring up.

Check each connection as you make it, and also again before you plug in the 8060. It's a good idea also to ensure that each LED is working before we have to start worrying about what the microprocessor is doing, so after checking the wiring, apply 5 V from a (preferably) stabilised supply (or use a 4.5 V battery), just to see what happens. None of the LEDs should light when the power goes on — put the room lights out, or pull the curtains to check this, because the glow from these small LEDs is a bit feeble. If all is well, no glow, use a piece of insulated wire with about 5 mm stripped from each end, as a checker. Plug one end of the wire into a spare hole in the +5 V row (X1 or Y2). Now plug the other end into a hole of one of the LED driving rows — try number A5 to start with. Check that the LED operated by this line (NENOUT on the 8060) is lit, and then try another one, such as A9. Check each LED in this way to ensure that you won't be let down by a faulty or reverse-connected LED, but make sure that you connect to the correct end of the limiting resistor. The miniature LEDs I used had one lead, the anode, longer than the other (Fig. 7), but a different variety of LED might be differently identified. Remember at this stage to check that there is an earth lead from the aluminium panel to the Eurobreadboard. The prototype used one of the Eurobreadboard fixing bolts to provide an earth simply by curling the bare end of a piece of single-core wire under it, and plugging the other end into the earth line on Y1.

While you have power on, check the effect of earthing line D18. This enables the buffers, so that with this line earthed each of the data switches, DBS0 to DBS7 should control its own LED DLED0 to DLED7.

The Final Link

With all of this checked out and working correctly, the final step can be taken. Switch off, remove the power supply leads, and put a shorting link between the + and — lines on the board (X1 and Y1). Take the INS8060 carefully out of its pack, locate the pip which identifies pin 1, and place the 8060 on the board so that its pin 1 lines up with line A1 of the Eurobreadboard. At this side of the board, the 8060 has to go off-centre — I allowed three spare holes at the side of the 8060 in the A column, and two spare on the B column.

Providing each hole has been pre-used by poking a lead into it, just take it off and put it back in its pack while you open each contact out a bit with a piece of 16 gauge wire, or the wire end of a large wire-ended capacitor. Then try again — and the INS8060 should slip in with just a gentle push. Everything is now ready for the first set of experiments detailed next month.

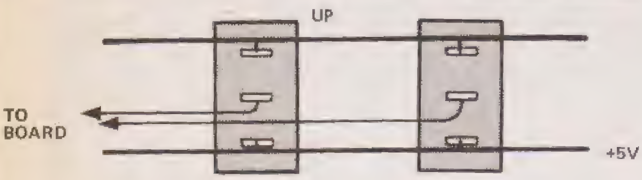


Fig. 6. How the toggle switches are wired.

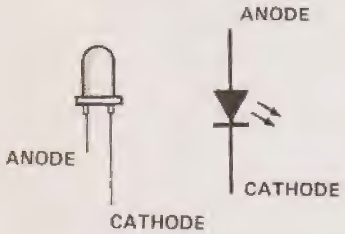


Fig. 7. Miniature LEDs as used in the prototype.

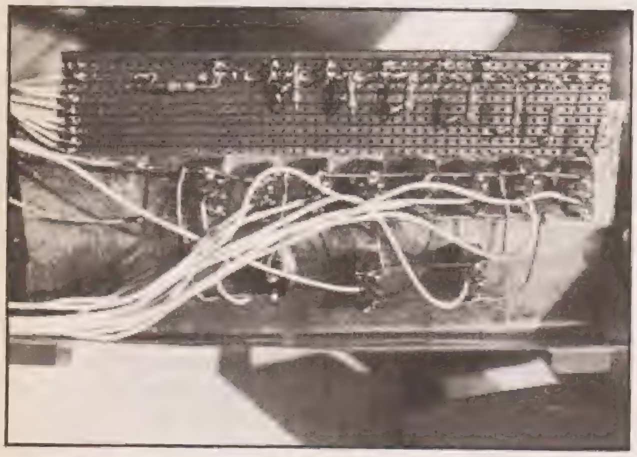


Fig. 8. The back of the panel after wiring — note the cuts in the Veroboard.

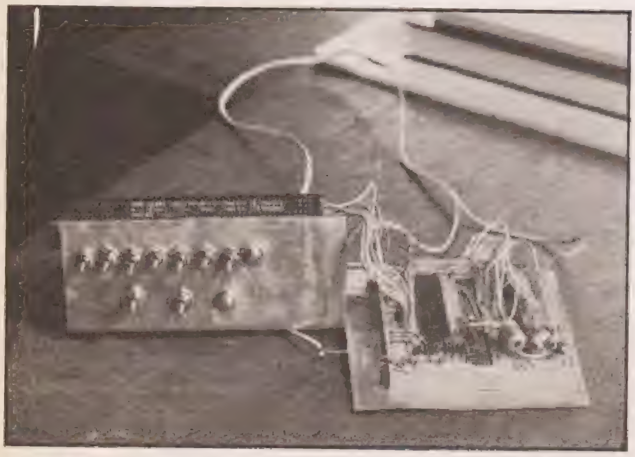


Fig. 9. The complete prototype — this was taken at a later stage, so that C+ is a smaller value, and another extra capacitor is visible. These changes are made in Part 3.

TABLE 1

USE OF INS8060 PINS

Pin	Label		Pin	Label	
1	NWDS	not used	21	FLG1	to LED
2	NRDS	operates gate	22	FLG2	to LED
3	NENIN	earthed	23	SOUT	to LED
4	NENOUT	to LED	24	SIN	from switch
5	NBREQ	4k7 to +5V	25	AD00	to LED
6	NHOLD	from gate	26	ADD01	to LED
7	NRST	from switch	27	ADD02	to LED
8	CONT	to + 5 V	28	ADD03	to LED
9	DB7		29	ADD04	
10	DB6		30	ADD05	
11	DB5		31	ADD06	
12	DB4	to buffers and	32	ADD07	All open-
13	DB3	LEDs	33	ADD08	circuit
14	DB2		34	ADD09	
15	DB1		35	ADD10	
16	DB0		36	ADD11	
17	SENSA	Earthed	37	XIN	from clock
18	SENSB	Earthed	38	XOUT	open circuit
19	FLGO	to LED	39	NADS	to LED
20	GND	to negative(earth)	40	VCC	to +5 V

INVENTORY

ICs

1 x INS8060
2 x 74LS126
1 x 74LS132

Other Semiconductors

20 x miniature LEDs (18 fitted intially, other two used later.)

Resistors

20 x 2k7; 1/8 W
6 x 10k 1/8 W
1 x 4k7 1/8 W
1 x 560R, 1/8 W

Capacitors, all 12V working or more.

1 x 0.1 uF
1 x 6.8uF
1 x 25 uF
1 x 250 uF

Hardware

1 x Eurobreadboard (later type with numbered rows and lettered columns).
10 x miniature toggle switches. (DBS0 to DBS7, SIN, RESET)
1 x miniature push-button switch (PUSH)
2 x 8BA bolts & nuts (to secure Eurobreadboard to panel)
Aluminium panel, about 260 mm x 100 mm
Wire, 18 gauge, solid core; or 1/0.6 mm
NOTE: DO NOT USE STRANDED WIRE FOR EUROBREADBOARD WIRING.

TABLE 2

EUROBREADBOARD CONNECTIONS

CHIPS: INS8060 Pin 1 on line A1
74LS126 No. 1 has pin 1 on line C1 ; No. 2 has pin 1 on C9
74LS132 Pin 1 on C17.

Supplies: X1 and Y2 are linked and used for +5 V.
X2 and Y1 are linked and used for earth.

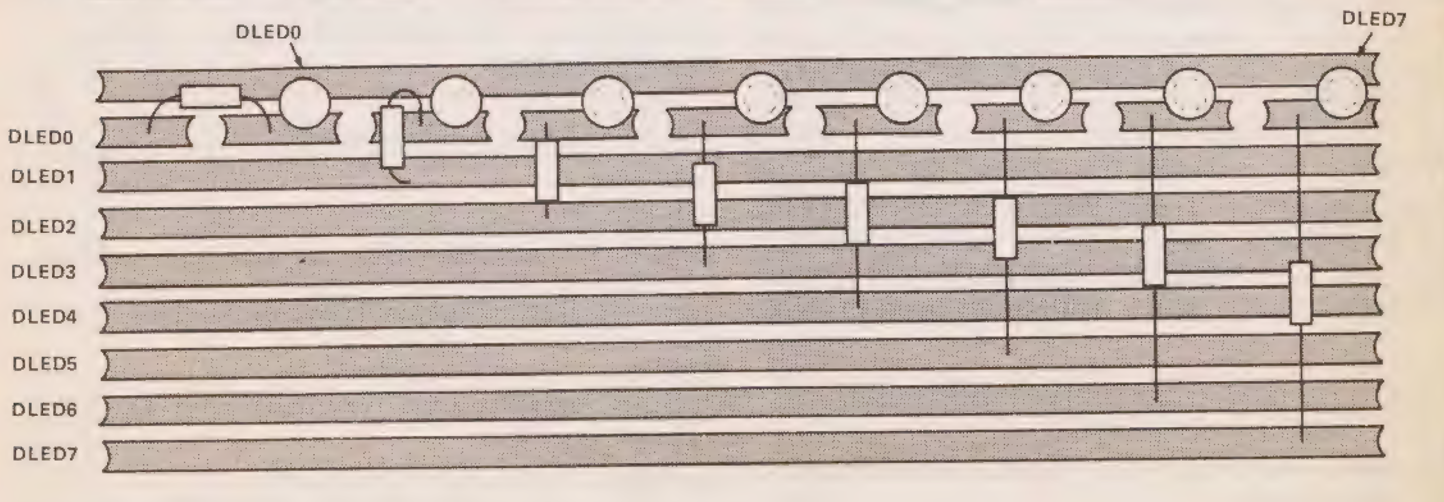
In the table, NC means no connections, and SW indicates a connection to a switch, the centre connection of the toggle switches.

Pin	Connection	Pin	Connection	Pin	Connection	Pin	Connection
A1	NC	B10	NC	C1	link to C8	D1	link to Y2
A2	link to X1; D18	B11	NC	C2	link to DBS7	D2	link to D8
A3	link to Y1	B12	NC	C3	link to A9	D3	link to DBS5
A4	2k7 to A22	B13	2k7 to B25	C4	link to C8	D4	link to A11
A5	4k7 to X1	B14	2k7 to B24	C5	link to DBS6	D5	link to D8
A6	link to D23	B15	2k7 to B23	C6	link to A10	D6	link to DBS4
A7	10k to Y1; reset SW	B16	2k7 to B22	C7	link to X2	D7	link to A12
A8	link to X1	B17	10k to X2. link to SIN SW	C8	links C1,C4,C9,C12,D20	D8	links D2,D5,D10,D13,D20
A9	link to DLED7; C3	B18	2k7 to C25	C9	link to C8	D9	link to Y2
A10	link to DLED6; C6	B19	2k7 to A25	C10	link to DBS3	D10	link to D8
A11	link to DLED5; D4	B20	2k7 to A24	C11	link to A13	D11	link to DBS1
A12	link to DLED4; D7	B21	NC	C12	link to C8	D12	link to A15
A13	link to DLED3; C11	B22	2k7 to B16; LED to X2	C13	link to DBS2	D13	link to D8
A14	link to DLED2; C14	B23	2k7 to B15; LED to X2	C14	link to A14	D14	link to DBS0
A15	link to DLED1; D12	B24	2k7 to B14; LED to X2	C15	link to X2	D15	link to A16
A16	link to DLED0; D15	B25	2k7 to B13; LED to X2	C16	NC	D16	links B2; 2k7 to D25
A17	link to Y1	B1	link to X1	C17	NC	D17	link to Y2
A18	link to Y1	B2	link to D16	C18	NC	D18	link to A2
A19	2k7 to A23	B3	NC	C19	NC	D19	10k to Y2
A20	link to Y1	B4	link to C22	C20	560R to C22; C^+ to X2	D20	links to D8; C8
A21	NC	B5	NC	C21	link to Y2	D21	10k to Y2
A22	2k7 to A4; LED to X2	B6	NC	C22	560R to C20; link to B4	D22	links to P/B SW; 10k to Y2
A23	2k7 to A19; LED to X2	B7	NC	C23	link to X2	D23	link to A6
A24	2k7 to B20; LED to X2	B8	NC	C24	NC	D24	NC
A25	2k7 to B19; LED to X2	B9	NC	C25	2k7 to B18; LED to X2	D25	2k7 to D16; LED to X2

Note: some of the NC lines are used later in the series.

ACKNOWLEDGEMENTS

I am very grateful to all the following who contributed, knowingly or otherwise, to this project.
Ben Mullett, of National Semiconductor, who patiently answered a lot of questions about slow clocking of the INS8060.
Greenbank Electronics, who supplied the 8060 and other chips, and are always so very helpful over the phone.
DTV, who rushed data books to me at a time when no-one else could supply them.
David George Sales, who supplied the Eurobreadboards.
Watford Electronics, who supplied other bits and pieces.
Curtis Lane & Co (Sudbury) who printed the photos.



10. Veroboard layout for LED and resistors, copper side. Note track breaks and check LED polarity before fitting.

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Mr D. Sinfield

After trying out the much publicised Superboard II for a month David Sinfield presents his report

The Superboard from Ohio Scientific is a ready-built single board Mostek 6502 based micro. On board there is 4K of RAM as standard and eight empty sockets for a further 4K. Further expansion is possible using the OSI 48 line bus. Ohio have peripherals available using this bus and I understand that they will be coming into this country soon. 8K Microsoft BASIC is in ROM as is the 65 V machine code monitor.

Wafercon sockets for cassette, video, and simply implemented RS232 ports are provided as well as the OSI bus, which is via a DIL socket. The wafercons are not ideal as it is difficult to provide a mechanically sound joint and if disturbed too often the wiring can come adrift.

The software scanned keyboard has 53 keys, positive but sensitive, but some of these seem to have no function. Auto repeat operates if any key is held down for more than about half a second.

On the documentation front there are four slim volumes entitled Users Manual, Technical Report, BASIC Reference Manual and Graphics Reference Manual. These get you through the initial stages of BASIC programming but anyone new to computing would be well advised to provide themselves with a decent BASIC text book and anything they could find on the 6502.

Having listed what you do get just a mention of what's needed before Superboard is up and running. First a power supply capable of 5 V @ 3 A (more if extra memory is added) with a ripple of less than 200 mV.

The video output is a conventional NSTC to run a monitor or a modified TV. If an unmodified TV is to be used a UHF modulator will be needed. Using our circuit the modulator can be encased with and powered by the power supply. All the components, including the modulator are readily available and only a modicum of electronic knowledge is needed to put them together. Alternatively a ready built PSU e.g. Tooting Computing "BIAS", can be obtained.

Any cassette can be used as long as it has a microphone input and extension speaker or earphone socket though some fiddling with the volume control may be necessary.

Orft We Jolly Well Go

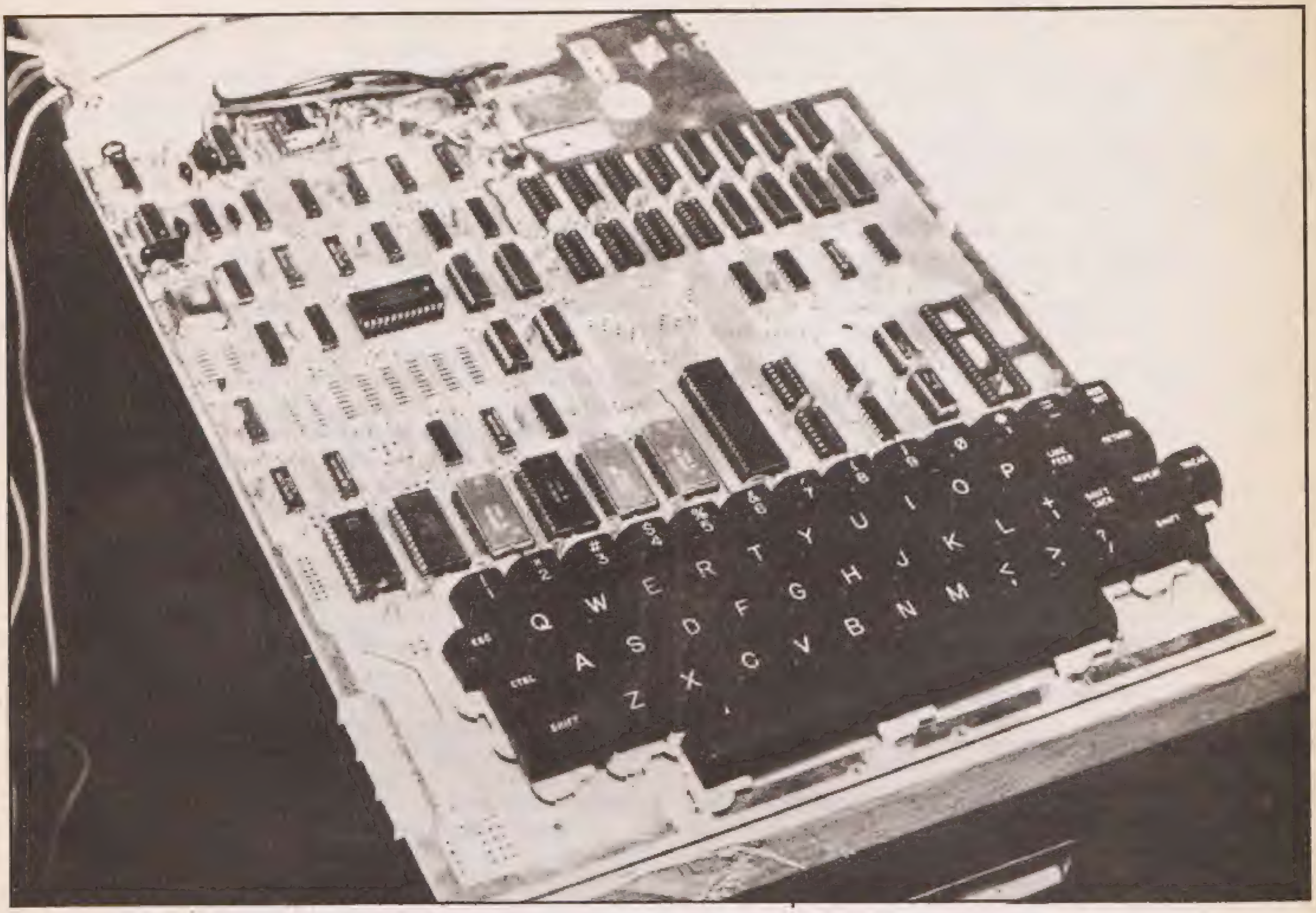
So with all the connections in the right places according to the instruction manual and the power on things should start to happen. Our first attempt lead to a "rolling" picture and as our TV didn't have the vertical hold control accessible we were stuck. The problem of course is that Superboard has a 60Hz sync pulse on the video to conform with the U.S. standard. Most TV's will lock up with no problem in fact out of 7 televisions I have tried the only two that didn't work were those in the C.T. offices! Wavering of the display can sometimes be cured by moving the power supply as far as possible away from the TV.

Assuming then that when switched on there is a steady display of random characters the machine is ready for use and can be initialised by pressing the break key. This produces the prompt "D C W or M". Before any key is accepted the shift lock key must be locked down. It is only used in the released position for lower case. D boots up the disc software and as I didn't have a disc I'll skip this one.

C stands for "cold start" and puts the machine into BASIC, clearing the RAM. At this stage the memory size can be specified. This enables memory space to be reserved and protected against everything except turning off and cold starting — very useful if the "clear screen" subroutine mentioned later is to be used. If memory size is not specified a memory test procedure is instituted and the amount of RAM available is reported. Terminal width can now be selected. A reply of between 16 and 72 inserts a carriage return after that number of characters. So formatting for a variety of printers and terminals is simple. The video output is limited to 24 characters per line so the display is only affected if a terminal width of between 16 and 24 characters is selected. In this case it can be used to compensate for right hand overscan, which can be a problem on some televisions. The machine I had was modified so that the horizontal framing of the picture could be adjusted. Setting the terminal width to 24 characters leads to two carriage returns being inserted, one from the VDU circuitry and one by the terminal width control, at the end of each line of display aiding ledgibility but of course halving the number of lines it is possible to get on the screen. The machine is now in BASIC mode but before going into this I'll mention the other two initialising modes.

W stands for "warm start" and calls up BASIC after a break without clearing RAM thereby preserving any programs that may be there. M after break calls up the monitor and programs can be written, inspected and run in machine code. The contents of one memory location are displayed and any location can be stepped to and its contents altered using the "/" and "." keys as described in table 2. Anyone wishing to use machine code on the Superboard should arm themselves with a 6502 manual, because the Ohio manuals are little help. I understand that there is a tape assembler

SUPERBOARD II REVIEW



The left hand photo shows the Superboard plugged into Lotus Sound's PSU and modulator box. On the right hand photo the spare RAM sockets are clearly visible at the rear right of the board. The veroboard add-on at centre rear is a slugging circuit to try to stabilize the timebase circuit so it will sync on 50Hz.

which is not generally available over here although your local Superboard supplier may be able to obtain one.

Back To BASIC

To anyone familiar with the BASIC language Microsoft's version will present few surprises. The full list of commands etc. available are given in the table. The only facility I hadn't seen before was being able to incorporate the list command in a program. Not something with any obvious use. But for a program requiring updating, the data statements can be listed along with explanatory REM's and then retyped by the user. Might work — mightn't it?

Error messages consist of one letter and a graphic and are adequately explained in the BASIC manual. Other than this the BASIC seems standard but is fast enough to make animated graphics in high level language feasible.

The Ins And Outs (Or How To Get Loaded And Save It!)

The only peripheral I had was a battered old cassette machine but according to the manual the procedure is much the same whatever you hang on the end of your Superboard.

The SAVE command does not produce immediate results but henceforth until a load command is encountered all that goes on to the VDU is written to the serial port.

Using the SAVE command not only programs can be recorded but sequential files can easily be set up using PRINT statements. As well as this, data files can be set up in the same way and used with INPUT statements in a program. The "trick" as the manual puts it is to make sure that the INPUT statement is encountered before the data.

The procedure thus for saving a program is SAVE (return key) LIST (return key) and as the program is written onto the screen it is also written to the cassette.

LOAD cancels any previous SAVE and opens the port for incoming information from cassette, modem or any other suitable source. The machine treats this information the same as if it had come from the keyboard and displays it as it is read.

All in all a very straightforward I/O system. The only thing it really lacks is both remote switching of the cassette and program search facilities. These two failings together can lead to some problems if more than one program is recorded per side of each cassette.

I have a couple of suggestions of how to make things easier; save a RUN command after each program or save a LOAD command. In this way even if programs follow one another very closely on the tape it is not so likely that the second will overwrite the first.

The Display

First impressions are that the alphanumerics are squashed vertically, an impression added to by the fact that there is very little separation between lines. It doesn't take long to

get used to though and the use of lower case in long screeds of text helps a lot. Characters are formed on an 8 x 8 MATRIX and include all sorts of wierd and wonderful shapes that go together to form the various gaming characters.

According to the graphics manual the display is 25 x 25 but I only counted 24 characters across. This may not sound very significant but it means that the screen locations for POKE and PEEK statements are not as shown on the matrix in the graphics manual. Add to this the fact that the memory location for the beginning of one line doesn't follow numerically from the end of the line above and you have unnecessary problems in POKEing graphics to specific locations. The "missing" screen locations are in fact to be found off screen to the right and this is where the Starship Enterprise goes to when it's not visible — It's not in hyperspace after all. A little experimental POKEing soon gives some idea of what is where in the VDU memory.

I have probably been spoilt by excessive use of the PET but I was a little disappointed not to find cursor control and this along with the fact that the most interesting graphics (racing cars, ships, subs, aircraft etc.) are not keyboard accessible means that POKE statements have to be relied on very heavily. Ohio are obviously well aware of this, because other than the error previously mentioned, the graphics manual gives excellent detail including numerical (hex and decimal) codes for all the characters.

Another omission on the display side is the lack of an in-built "clear screen" function and to achieve this the manual suggests that you either:

POKE character 32 to each screen location in turn using a FOR.NEXT loop,

PRINT a series of carriage returns, again using the FOR.NEXT loop,

or use a BASIC program (given in the manual) to POKE a sub routine.

The latter is by far the most satisfactory, the routine being called at any time during a BASIC program using the USR command.

Expansion

As well as the 8 spare RAM sockets on board the memory can be expanded via the 48 line bus. According to the manual Ohio have lots of plug-in goodies including memory, disks, A/D,D/A etc. and no doubt they will be filtering into this country — hopefully in a steadier stream than they have been so far.

Also mentioned in the manual is a wide variety of software from the manufacturers. As well as the assembler already mentioned there are business packages, games and educational programs and these will be available over here as soon as demand for them increases. Interfacing to an RS232 device requires a few extra components but seems easy enough to accomplish using the manual.

Summing Up

Overall a useful machine despite my grouses on the display. Certainly at around £300 up and running for 4K RAM and 8K BASIC in ROM Superboard represents value for money. It is very tempting to compare the machine with others available but it seems to fall in between the extremes. It is not merely the enthusiasts machine it appears at first sight, the BASIC and potential for adding peripherals such as disc and printers without too much modification must mean that "serious" users will find it worth a look.

Our thanks are due to Lotus Sound for lending us the machine for a generous period, in order to prepare an accurate report of its facilities.

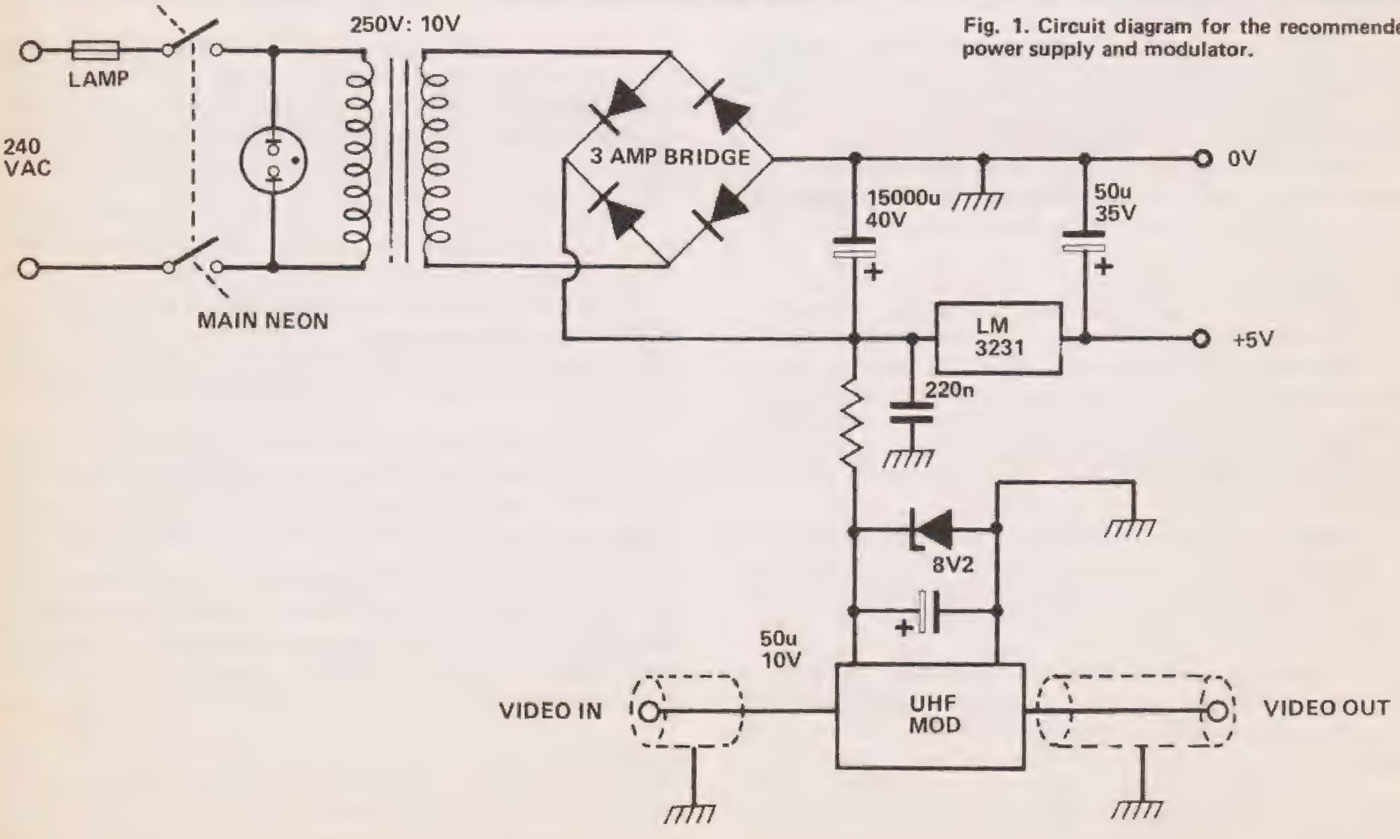


Fig. 1. Circuit diagram for the recommended power supply and modulator.

Table 1

BASIC commands available

LIST	Lists program Range of lines to be listed can be specified
RUN	Starts program execution at lowest line number Line number for start may be specified
NEW	Deletes current program
CONT	Continues program after a Control C or STOP
LOAD	Alerts machine to input from serial port
SAVE	Causes subjects of PRINT or LIST statements to be written to serial port

Operators

=	Assigns value to variable
–	Negation
	Eponentiation
*	Multiplication
/	Division
+	Addition
<>	Inequality
>	Is greater than
<	Is less than
⩽	Is less than or equal to
⩾	Is greater than or equal to

Statements

DATA	When READ is encountered information is taken sequentially from DATA statements
DEF	Identifies a user defined function
DIM	Defines dimension(s) or array(s)
END	Terminates program
FOR.NEXT	Used for incremental loops. Size of step can be specified
GOTO	Jumps to line specified. Can be incorporated into IF statements
IF.THEN	Conditional statement. The THEN will only be executed if the IF is true. Can incorporate AND, OR or NOR.
GOSUB.RETURN	Jumps to specified line number. On encountering RETURN program jumps to line number following GOSUB
INPUT	Takes in data from keyboard or cassette
POKE	Loads specified memory location with value
PEEK	Determines value of specified memory location
RESTORE	Restores initial values of DATA statements
PRINT	Outputs information. Can be abbreviated to ?.
STOP	Stops program execution, program can be restarted using CONT

Functions

ABS	Returns the absolute value of variable ignoring sign
INT	"Rounds down" and returns next lowest whole number
RND	Generates random number
SGN	Positive numbers result in "1", negative numbers result in "0"
SIN COS TAN ATN	Trig functions (machine works in radians)
SQR	Square root
TAB	Spaces print head
USR	Jumps to machine code sub-routine
FRE	Gives number of bytes left in workspace
LOG	Returns natural Log
POS	Returns position of terminal print head
SPC	Returns specified number of spaces

Strings 'n' Things

Any character or group of characters in a string can be isolated using LEFT$, MID$ and RIGHT$. Strings are permitted up to 255 characters long.

Table 2

Special key functions

@ (shift P)	Erases line being typed
– (shift 0)	Erases last character
Control C	Interrupts execution of program or list.
"/"	Amend contents of memory location displayed
"."	Step to specified memory location
G	Goto specified location and runs program

The twin mini floppy disc system provides off line storage of programs and data using IBM 3740 compatible formating providing 128 bytes per sector 16 sectors per track 40 tracks per disc. Media is reversible.

The drive and controller are housed in a saddle maintaining an integrated configuration, one of the major features of the PET. Connection is via the PET memory or IEE port. The system comes complete with a PROM for booting the disc resident P-DOS into RAM. P-DOS is completely transparent to BASIC. Control of the disc system is via PET BASIC USR instruction with simple commands from either the keyboard or under program control.

The following commands are available LOAD, SAVE, CREATE, DELETE and CATALOGUE. The file management system provides for up to 8 files to be opened concurrently. Files can be opened in READ, WRITE, UPDATE and APPEND mode. The user may write his own disc system modules to expand the facilities of the disc resident system.

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Triton Breakpoint Routine

Mr. Andrew F. Lack

Unfortunately the standard TRITON monitor (V4.1) does not have a BREAK routine. A break routine allows the user to break a machine code programme and to examine the status of all the internal registers — it is a kind of 'snapshot' of the inside of the CPU where it is believed a fault may be occurring.

This snapshot must give the status of the flags as well as the internal registers. The biggest problem is how to convert the binary contents of the registers to 2 hexadecimal digits, and then print them. This is easily got round here by making use of the stack pointer and the monitor's LIST routine, which converts bytes of RAM into 2 hex digits. The routine is called by interrupt 3 — a halt instruction (76) being placed in the next 'valid' instruction byte following the suspected fault (i.e. not inside an address field, for example). When the CPU halts, it will respond to interrupt 3, and jump to Debug and stop again. List can be called via an interrupt 2 and then the register's status can be found. Debug, listing and use.

```
1618   C3   F0   14   ;JMP, 14F0    Call to debug

Debug
 14F0  31   F0   14   ;LXI SP, 14F0
 14F3  F5             ;PUSH PSW
 14F4  C5             ;PUSH B
 14F5  D5             ;PUSH D
 14F6  E5             ;PUSH H
 14F7  FB             ;EI
 14F8  76             ;HALT
```

Use

As stated above, 76 (HALT) should be entered after the fault (or suspected fault). Interrupt 3 is then operated, and then interrupt 2 to take the user to the monitor L14E1 is entered and this lists the region of RAM that holds the registers contents. The RAM is designated as follows:—

14E8	L
14E9	H
14EA	E
14EB	D
14EC	C
14ED	B
14EE	Flags (PSW)
14EF	A

The contents of the SP and PC is not, however, held on the stack.

Debug gives the PSW at the instance of call. The PSW is made up as follows:—

7	6	5	4	3	2	1	0	BIT NO.
S	Z	0	AC	0	P	I	C	

Note that bits 3 and 5 are always 0 and bit 1 is always I.

Thus, if for example the data in byte 14EE was 95 after a debug call, then this would correspond to the flags S, AC, P being set and the flags Z and C being reset. Parity is set for even parity, and S is set for negative numbers (based on the two's compliment nomenclature).

It should be remembered that bytes 1618 . . . 161A (inclusive) are reserved for the debug call address. Thus the user programme should jump round this:

```
1615   C3   1B   16
1618   C3   F0   14
161B   . . . user programme
```

Nascom Random Number Generator

Mr. E. A. Parr

The subroutines were written to provide a random number in the range 1 — 6 (i.e. a dice) for a games program running on the Nascom 1.

Several unsuccessful programs were tried which ended up giving continuous 00 or a fixed sequence. The final solution is very simple, whenever the computer is waiting for an input from the keyboard, it sits "rolling the dice" giving a true random number.

The number is held in OC50 and is read by the rest of the program. Obviously there has to be a keyboard input prior to each read of the dice.

OC50	Dice	01	Holds value of DICE
1	ROLL	3A 50 0C	Ld Dice
4		3C	Inc A
5		FE 07	Compare with 7
7		20 02	Skip if not 7
9		3E 01	Load A with 1
B		32 50 0C	Replace dice
E		C9	Return
OC5F	INPUT	CD 51 0C	GO SUB ROLL
OC62		CD 69 00	GO SUB NASBUG INPUT FROM KBD
5		30 F8	Jump back to input if no key pressed
7		C9	Return

When a character is required from the keyboard the instruction:—

CD 5F 0C GOSUB INPUT

enters the subroutines, and they return with the character in A and location OC50 randomised in the range 1 — 6.

What to look for in the August Issue: On sale July 6th

STRING THING

To call this project an electronic piano would be an injustice. To call it a string ensemble likewise fails to explain all the mysteries and beauties awaiting the builder once this beast is activated. Yes it can be a piano. Yes it can play string sounds.

The designer (Tim Orr who also can be blamed or praised for the Transcendent 2000) wanted to call it a "Digital Multi-Voice String Synthesising Keyboard Instrument". But we wouldn't let him. We couldn't think of a better title ourselves, but we still wouldn't let him. It's the way we are.

Being fitted with a CCD choraliser allows our String Thing to sound like several of 'em at once. Why not tune in and be amazed next month?

BENCH AMPLIFIER

One for the workshop or table top. How many times have you been half-way through a project and needed to test something, somehow, somewhen. And that of course is exactly when it occurs to you that there is nothing around suitable.

A bench amp is worth its weight in soldering ten times over, and if you DON'T build this you will regret it.

MICROSENSE

MPUs are definitely for you. Oh yes they are, don't give me that old line about them being all covered in mystery and incomprehension. MPUs are nice friendly little chips, and next month we've got the definitive article to prove it. Based on a book by John Miller Kirkpatrick it takes you through the subject from scratch in a thorough but light-hearted manner.

LED AUDIO DISPLAY

A really lovely little design to amaze, astound and hypnotise the entire universe. This project takes the input from your hi-fi or TV or budgie and turns it into a dazzling and bemusing shifting pattern of light upon a LED matrix.

Build it any size you like it'll add a bit of visual spice to the hi-fi rack — or simply keep mother-in-law quiet while you nip off down the local.

Mr M.J. Bell

This months NASCOM program is for a sort routine

Sort routines are many and various depending on the type of information that is required to be sorted. The way in which the sorting is carried out can be complex, and many books have been written on the subject.

I have chosen the "bubble" method because it is particularly suited to the small microprocessor and is easy to understand.

What Does It Sort

The program has been designed to sort up to 65 entries of data each with a maximum length of seven characters and a minimum length of 1 character. It will handle both numbers and words or a mixture of both displaying the result with numbers first.

e.g. 86, 2, FRED, CAT4, JOHN, 3862, CAT40, XYZ.
Sorted to 2, 86, 3862, CAT4, CAT40, FRED, JOHN, XYZ.

The possible uses are therefore to sort; numbers, words, names, dates, catalogues etc.

The writer has found that 65 entries of mixed length and form have taken less than 3 seconds to be processed.

The Program

The program is entered at address OC50. The screen is cleared and the instruction "LOAD DATA NOW" is displayed. Data is entered from the keyboard, each item separated by a comma ",". The data entered will be tabulated on the screen. Backspace is operative for the current item ONLY. When all the data has been entered an equals "=" will initiate the sort. While sorting is taking place "WAIT" is displayed at the top of the screen. On completion the sorted data is displayed in tabular form with the legend "** DATA SORTED **". If another set of data is required to be processed, depressing the "space" bar will reinitialise the program.

This program will sort words or numbers or letters, or a combination of both, up to a maximum of seven characters in length. To restart the program after a sort the "Space Bar" should be pressed.

MAXIMUM NUMBER OF WORDS IS 65

EXECUTE FROM 0C50

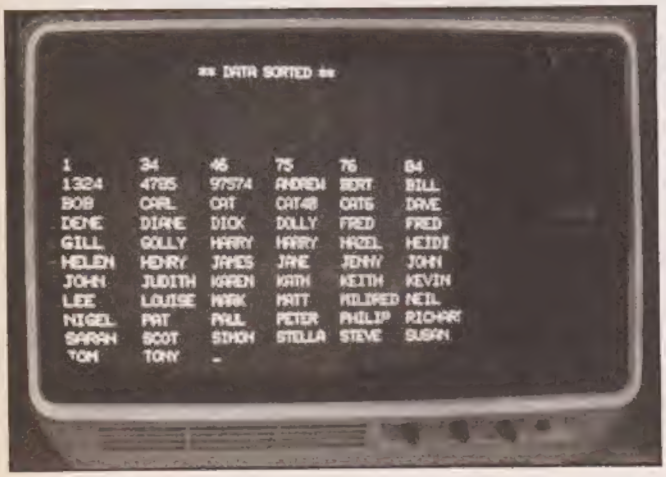
```
C50   3E 1E      'START'   A = 1E
C52   CD 3B 01             Call CRT
C55*  01 08 00             BC = 0008
C58   21 DF 0C             HL = 0CDD
C5B   11 E2 0C             DE = 0CE0
```

The authors NASCOM installed with cassette in a cabinet.

```
C5E   D9                      EXX
C5F   21 C8 0D                HL = 0DC8
C62   11 C9 0D                DE = 0DC9
C65   01 20 02                BC = 220H
C68   36 00                   (HL) = 0
C6A   ED B0                   LDIR
C6C   01 D4 0B                BC = 0DD4
C6F   21 8B 0D                HL = 0D8B
C72   CD 82 0D                Call PRINT

GET DATA
C75   21 C8 0D                HL = 0DC8
C78*  06 08        'GD1'      B = 8
C7A   CD 3E 00     'GD2'      Call CHIN
C7D   FE 2C                   CP = 2C
C7F   28 15                   JRZ – 'GD4'
C81   FE 3D                   CP = 3D
C83   28 1B                   JNZ – 'TEST'
C85   CD 3B 01                Call CRT
C88   FE 1D                   CP = 1D
C8A   20 04                   JRNZ – 'GD3'
C8C   2B                      Dec HL
C8D   04                      INC B
C8E   18 EA                   JR – 'GD2'
C90   77           'GD3'      (HL) . A
C91   23                      INC HL
C92   10 E6                   DJNZ – 'GD2'
C94   18 E2                   JR – 'GD1'
C96   CD 3C 02     'GD4'      Call SPACE
C99   23                      INC HL
C9A   10 FA                   DJNZ – 'GD4'
C9C   18 DA                   JR – 'GD1'

TEST
CA0   01 E1 0B                BC = 0BE1
CA3   21 A7 0D                HL = 0DA7
CA6   CD 82 0D                Call 'PRINT'
```



A typical screen display after a sorting run. Read the display left to right, row by row.

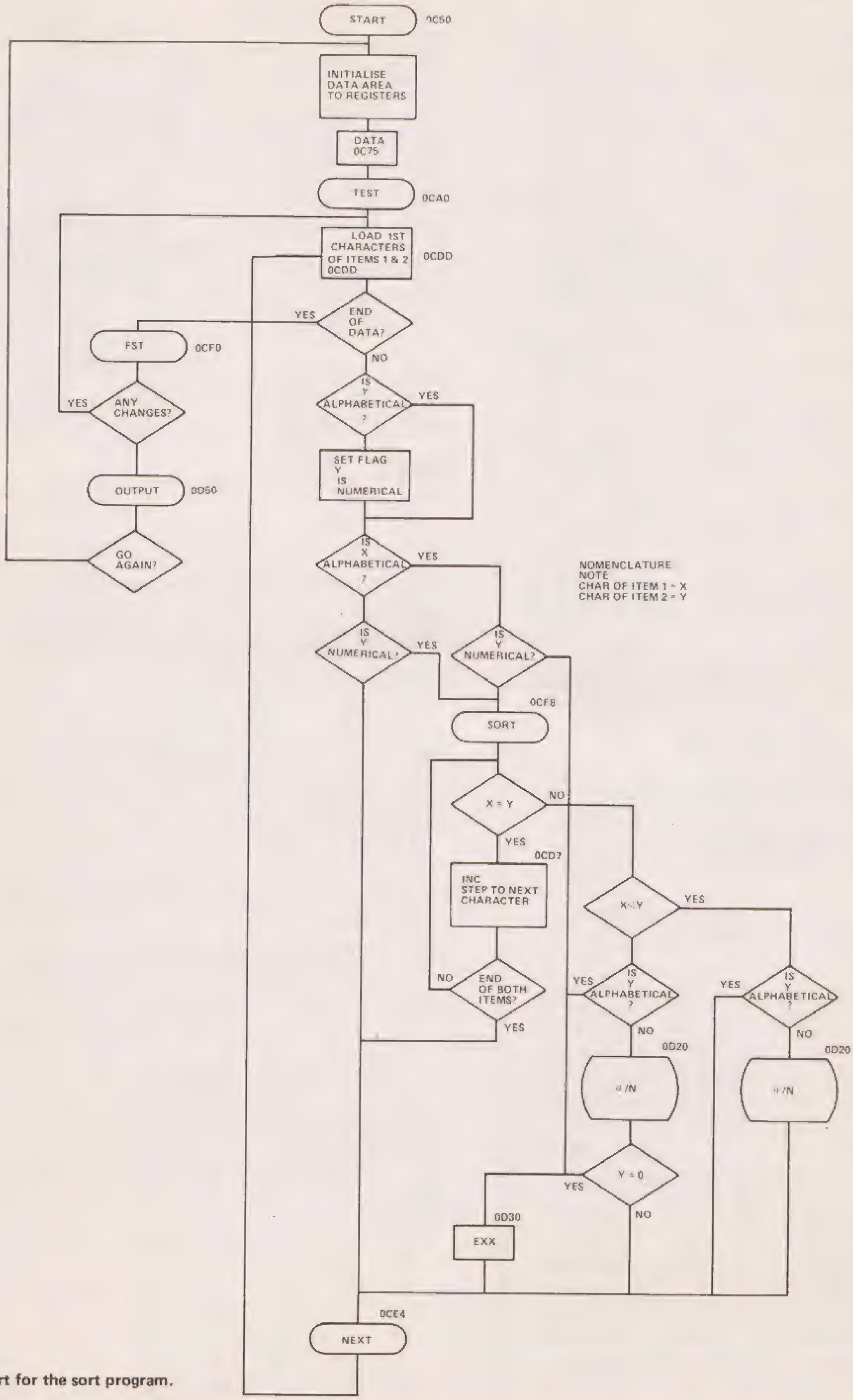
```
CA9   D9               'TEST 0'   EXX
CAA   77                          (HL) . A
CAB   12                          (DE) . A
CAC   D9                          EXX
CAD   DD 21 C8 0D                 IX = 0DC8
CB1*  FD 21 D0 0D                 IY = 0DD0
CB5   CB 93                       RST E BIT 2
CB7   CD DD 0C         'TEST 1'   Call 'LOAD'
CBA   B9                          CP = C
CBB   28 33                       JRZ – 'FST'
CBD   3E 3A                       A = 3A
CBF   B9                          CP = C
CC0   38 04                       JRC – 'TEST 2'
CC2   CB 8B                       RST E BIT 1
CC4   18 02                       JR – 'TEST 3'
CC6   CB CB            'TEST 2'   Set E Bit 1
CC8   B8               'TEST 3'   CP = B
CC9   38 06                       JRC – 'TEST 4'
CCB   CB 4B                       TEST E BIT 1
CCD   28 29                       JRZ – 'SORT'
CCF   18 13                       JR – 'NEXT'
CD1   CB 4B            'TEST 4'   TEST E BIT 1
CD3   28 5B                       JRZ – 'EXX'
CD5   18 21                       KR – 'SORT'

INC
CD7   D9                          EXX
CD8   34                          INC (HL)
CD9   EB                          EX HL, DE
CDA   34                          INC (HL)
CDB   EB                          EX HL, DE
CDC   D9                          EXX
CDD   DD 46 00         'LOAD'     B, (IX+d)
CE0   FD 4E 00                    C, (IY+d)
CE3   C9                          RTN

NEXT
CE4   D9                          EXX
CE5   DD 09                       ADD IX, BC
CE7   FD 09                       ADD IY, BC
CE9   AF                          X0R A
CEA   77                          (HL) A
CEB   12                          (DE) A
CEC   D9                          EXX
CED   18 C8                       JR – 'TEST 1'

FST
CF0   CB 53                       TEST E BIT 2
CF2   28 5C                       JRZ – 'OUTPUT'
CF4   18 B3                       JR – 'TEST 0'

SORT
CF8   78                          A, B
CF9   B9                          CP = C
CFA   20 05                       JRNZ – 'SORT 1'
CFC   CD D7 0C                    Call 'INC'
CFF   18 1A                       JR – 'SORT 3'
D01   38 0C            'SORT 1'   JRC – 'SORT 2'
```



The flowchart for the sort program.

```
D03   CB 4B                    TEST E BIT 1
D05   20 29                    JRNZ – 'EXX'
D07   CD 20 0D                 Call 'a/n'
D0A   B9                       CP = C
D0B   28 23                    JRZ – 'EXX'
D0D   18 D5                    JR – 'NEXT'
D0F   CB 4B       'SORT 2'     TEST E BIT 1
D11   20 D1                    JRNZ – 'NEXT'
D13   CD 20 0D                 Call 'a/n'
D16   00                       NOP
D17   18 CB                    JR – 'NEXT'
D19   00 00                    NOP NOP
D1B   81          'SORT 3'     ADD C
D1C   28 C6                    JRZ – 'NEXT'
D1E   18 D8                    JR – 'SORT'

'a/n'
D20   AF                       A = o
D21   CD D7 0C                 Call 'INC'
D24   B8                       CP = B
D25   C8                       RZ
D26   B9                       CP = C
D27   28 07                    JRZ – 'EXX'
D29   18 F6                    JR – 'a/n'

EXX
D30   D9                       EXX
D31   AF                       XOR A
D32   77                       (HL), A
D33   12                       (DE), A
D34   D9                       EXX
D35*  06 08                    B = 8
D37   CB D3                    Set E Bit 2
D39   D5                       PUSH DE
D3A   DD E5                    PUSH IX
D3C   FD E5                    PUSH IY
D3E   D1                       POP DE
D3F   E1                       POP HL
D40   4E          'EXX 1'      C, (HL)
D41   1A                       A, (DE)
D42   77                       (HL), A
D43   79                       A. C
D44   12                       (DE), A
D45   23                       INC HL
D46   13                       INC DE
D47   10 F7                    DJNZ – 'EXX 1'
D49   D1                       POP DE
D4A   18 98                    JR – 'NEXT'

OUTPUT
D50   3E 1E                    A = 1E
D52   CD 3B 01                 Call CRT
D55   21 B6 0D                 HL = 0DB6
D58   01 D9 0B                 BC = 0BD9
D5B   CD 82 0D                 Call 'PRINT'
D5E   21 C8 0D                 HL = 0DC8
D61   AF          'O/P 0'      XOR A
D62   BE                       CP = (HL)
D63   28 17                    JRZ – 'END'
D65*  06 08       'O/P 1'      B = 8
D67   7E          'O/P 2'      A, (HL)
D68   FE 00                    CP = 00
D6A   28 08                    JRZ – 'O/P 3'
D6C   CD 3B 01                 Call CRT
D6F   23                       INC HL
D70   10 F5                    DJNZ – 'O/P 2'
D72   18 F1                    JR – 'O/P 1'
D74   23          'O/P 3'      INC HL
D75   CD 3C 02                 Call SPACE
D78   10 FA                    DJNZ – 'O/P 3'
D7A   18 E5                    JR – 'O/P 0'

END
D7C   CD 3E 00                 Call CHIN
D7F   C3 50 0C                 JP – START

PRINT
D82   7E                       A, (HL)
D83   FE 00                    CP = 0
D85   C8                       RZ
D86   02                       (BC), A
D87   03                       INC BC
D88   23                       INC HL
D89   18 F7                    JR – 'PRINT'

MESSAGES
1     D8B     **,SORT,**,,,,LOAD,DATA,NOW@
2     DA7     ,,,,, WAIT,,,,,@
3     DB6     **,DATA,SORTED,**@

DATA MEMORY
DC8 – FEO
```

* Locations to be changed for different entry lengths (See Table 1)

Note "," indicates a "space" and @ indicates 00Hex

SORT
TABLE 1

To change the length of the entries make the changes as shown in the table below: –

entry length (decimal)	0C56	0C79	0CB3	0D36	0D66	max number of entries (decimal)
3	04	04	CC	04	04	130
7	08	08	D0	08	08	65
15	10	10	D8	10	10	32
23	18	18	E0	18	18	21
47	30	30	F8	30	30	10

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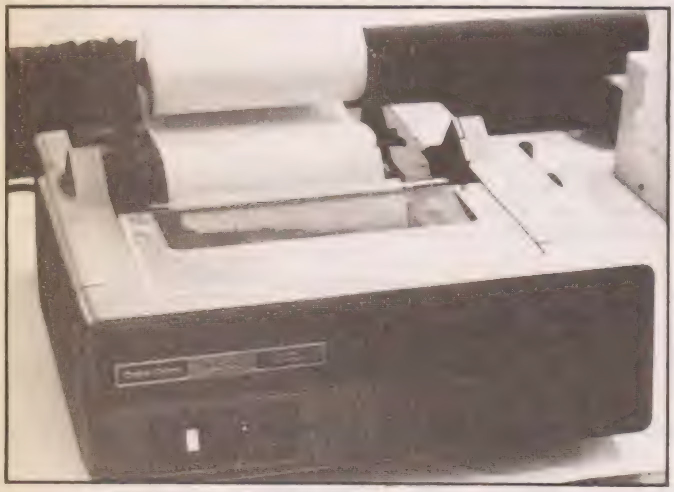


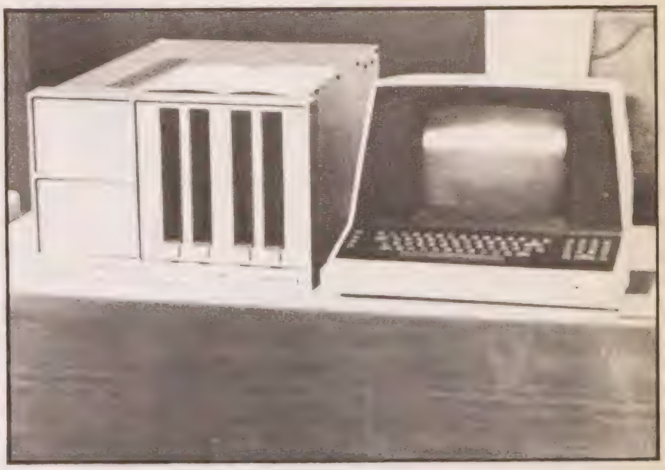
American shows. One up on England?

It is a rare event nowadays if a month goes by without at least one invitation to a Press reception or exhibition, with its attendant food and drink. The rate of change in the industry today tends to mean that if you miss out on going to one of these you may well miss something of vital importance. Sods Law and all that! On the other hand of course if you go to all of them then you never get any work done at all.

At the beginning of April news of a show reached my ears, shows are getting almost as common as Press do's now, and this one really caught my attention. It was to be held in sunny Florida. Visions of sun, palmy beaches, sun-tanned bodies all appeared before me so I went to see if the Editor's arm could be twisted. After a considerable amount of very hard bargaining it was agreed that I could go so the rest of my story is told in words and pictures from the show.

I should point out at this early stage that I am by no means a professional photographer and the quality of some of the photographs may have suffered due to an excess of the duty-free whisky and a local brew known as "Flaming Hurricane".

Anticlockwise:— Bright and early on Saturday morning, the attendance was well up on Friday but still no crowds. A new Tandy printer, Centronics by looks, will it come over here? A small business system based on the Horison but with double density disks.



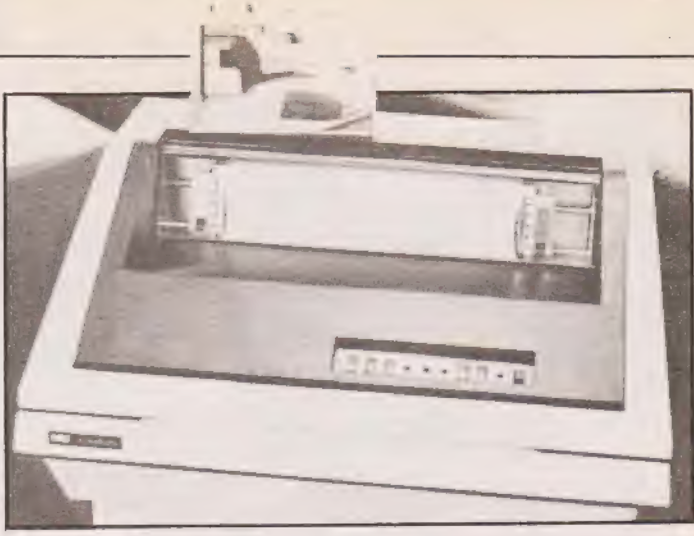
Micro-computers, Micro-show

The show itself was called the Southern Micro-computer Industries Show, SMIS for short, and was held in Exposition Hall, Orlando, Florida. It really was a Micro-fair in all the senses of the word as there were only about two dozen exhibitors present. I attended on both the Friday and Saturday, mainly to avoid the bulk of the general public, talked to as many of the local exhibitors as I could, and sat in on a couple of the seminars as well. For the general public the show cost $3, that's about £1.50, but that included free access to the seminars as well so the price was not too high.

The tone of the whole show was very informal with everybody willing to talk and be of any assistance to the public, a welcome change from some of the British shows that I have been to. The thing thst seemed to suprise them most of all was to find a British journalist wandering around!

The areas of interest that the show covered were from the home and small business systems area, there was only one stand that was selling anything at all for the home constructer. The range of machines on show was very varied, they ranged from an AIM 65 right up to an LSI 11, but there some notable exceptions, not a single PET or KIM or even a Superboard. There was only one new machine there called the INFORMER, an SCMP/Z80 based machine running on the ubiquitous S100 bus with integral discs. Unfortuneately there appears to be little hope of it arriving on this side of the puddle.

Clockwise:— A wierd Tandy game called Eggs. The excellent Cromenco Three running a business system. The old and faithful Imsai VDP 80 with its neat integral disks, again running a small business system. The sharp end of a 747, the INS is the central console and is computer controlled. The aircraft flies between accurately known points on the Earth.

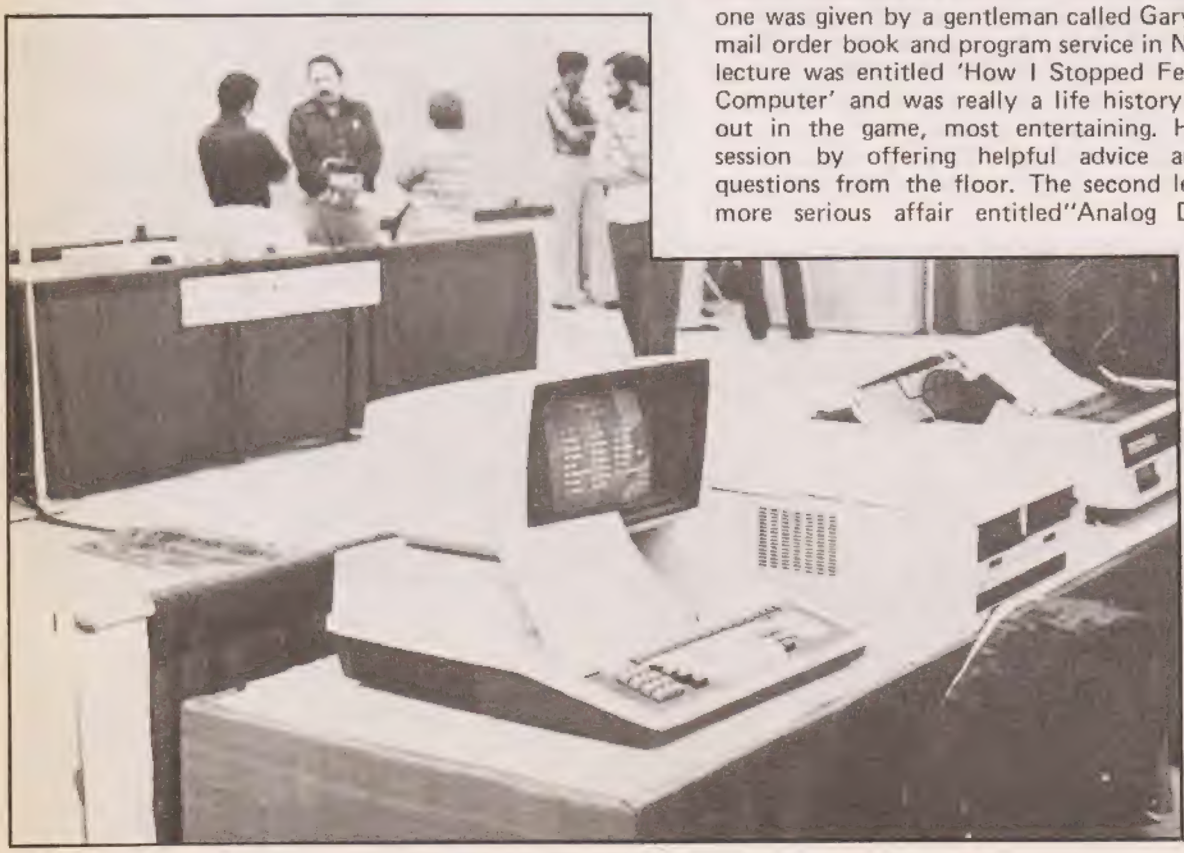


As you will be able to see from some of the photos the American versions of familiar machines are sometimes slightly different, the Compucolor that we reviewed last month has had another facelift, apparently to iron out a few bugs that we did not find when we reviewed the machine last month. The new look machine will be the one that is shipped over here apparently.

British Micro's?

A large number of the exhibitors had not even heard of such famous British systems as Nascom, Rair or Micros but a generally expressed view was a desire to come over to Europe and see just what is going on. The pricing of systems over here raised even more eyebrows, the Dollars to Pounds rule still seems to be holding true unfortunately.

Some of the most amusing moments of the whole show were to be found in the seminar hall, I attended three of the lectures and found them all to be on a very low technical level and held almost like a club evening. The first one was given by a gentleman called Gary Dozier who runs a mail order book and program service in New Hampshire. The lecture was entitled 'How I Stopped Fearing & Loved The Computer' and was really a life history of how he started out in the game, most entertaining. He finished off the session by offering helpful advice and answering any questions from the floor. The second lecture was a rather more serious affair entitled"Analog Devices—Real Time



Anticlockwise:— A new high-speed line printer from NEC being used to generate "computer photos". An Attache stripped down. A Texas 9900 based machine with integral dual cassettes and thermal printer, dual floppies and a Centronics 702 on-line. It played a real mean game of Star Trek.

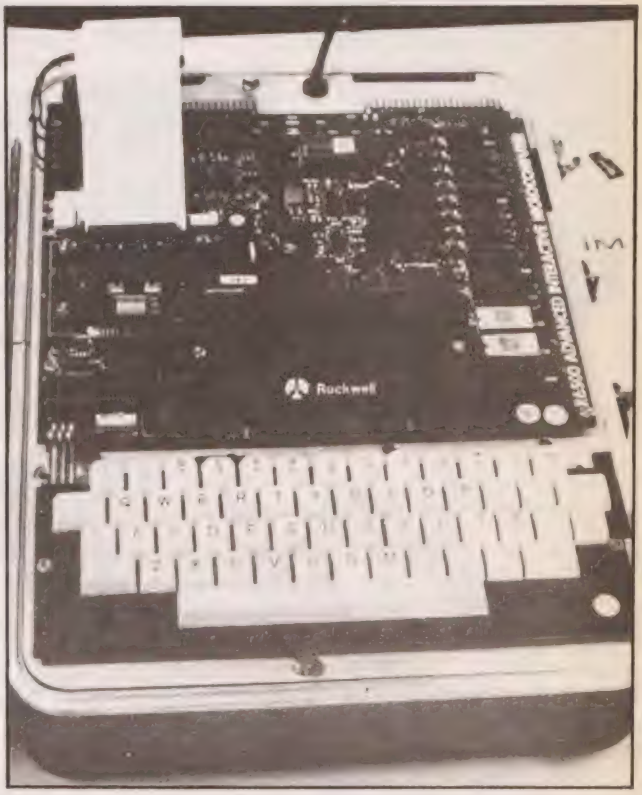
Interface To Microprocessing" in which Gary Miller explained just what you could do with an analogue input board and how this helped you to control your environment with an analogue output board, this was in fact the best given talk on the subject that I have heard and I think quite a few people produced their cheque books at this stand in the main hall.

The third talk was given on "The Role Of Microcomputers In Business Today" by Mike Kelly of Veytec Inc. but was really about the use of modems and how to connect up your home micro to your business machine over the telephone. The Americans seem to have little problem in hooking up modems unlike this country, that possibly accounts for the large proportion of the home computer people in that country who use on-line systems.

In Excelsis

In summary the show was well worth attending as it revealed a lot about what makes the American market tick, as well as establishing valuable links with their personnel. As for the thoughts of sun, sea and sand? It rained!

Many thanks are due to the people who made my brief visit a pleasure, Mr Bud Felsburg who organised the show, Mr Gary Dozier and Mr Gary Miller who introduced me to the American drinking habits and to Capt. Thomas of British Airways who allowed me on the flight deck of the 747 to take some photos, most of which Miami customs ruined with their 'safe' X—Ray machine.



Clockwise:— A reconfigured Compucolor with its new keyboard. The bugs that occurred with the HT have been ironed out. Gary Miller expounding on Analog Devices. An AIM 65 in a briefcase, with its accoustic coupler it can be used as a remote system. Not a Superboard but the guts of a Challenger.

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CLUB SURVEY

UK Club roundup

For a long time we have wanted to publish a listing of as many UK computer clubs as possible and at last this ambition has been achieved. While this list is by no means an exhaustive survey we hope that it will encourage those of you who have a club to write in and tell us all about it, and also to provide a service to those clubs that we have mentioned in bringing more members into your ranks. We would like to thank those clubs that regularly correspond with us for their help in producing the survey and wish them and all the rest of you a successful future.

Please address any mail for publication under the club news section to:–

Club Forum, CT, 145 Charing Cross Road, London WC2
as we will shortly be moving to this new address.

The format of the clubs mentioned in this report is as follows:

Primary contact and address if known, Telephone number if known, Approximate membership:Primary meeting day and week of month:Membership fee:Special membership if known:Features and services if known.

If we get a suitable response to this feature we will endeavour to publish an update at least four times a year so the future is in your hands.

Processor Groups

UK PET Users Club
Commodore Systems, 360 Euston Road, London NW1 3BL
Richard Pawson, newsletter Editor
0926–25942
1500: :£10 UK,£15 o'seas:Newsletters.

Independant PET Users Group
Mike Lake, 9 Littleover Lane, Derby
Derby 23127
250: :£2.50:

PET User Group
Norman Fox, 22 Firs Walk, Tewin Wood, Welwyn, Herts.
Bulls Green 433

Northeast PETS
Mr T Turnbull, 49X 9th Row, Ashington, Northumberland

TRS80 User Group
Brian Pain, 40A High Street, Stony Stratford, Bucks.

TRS 80 User Group (Chelmsford)
Michael Dean, 22 Roughtons, Galleywood, Chelmsford, Essex
0245–76127

Hull And District TRS80 Users Club
Frederick Brown, 421 Endicke Lane, Hull
0482–859169
:Tu3:

TRS80 Users Group
Leon Heller, 8 Morris Walk, Newport Pagnell, Bucks

Nascom User Group Nascom Microcomputers
121 High St., Berkhampstead, Herts HP4 2DJ
Miss Beverly Hamill
04427–74343
2000: :£1 & £5: :Newsletters:Program Library

Independant Nascom Users Group
Reliance Buildings, Damside Street, Lancaster
0524–33596
:£5:Newsletters, Program exchange

Sorcerer Program Exchange Club
G F Counsell and M P Hannaby, 65 Trafalgar Road, Birkdale, Southport, Merseyside

Cosmac Users Club
James Cunningham, 7 Harrowden Court, Harrowden Road, Luton LU2 0SR

Cromenco Users Group
313 Kingston Road, Ilford, Essex

77/68 User Group
Newbear Computing Store, 40 Bartholomew Street, Newbury, Berkshire
0635–30505
600: :£1.50: :Newsletters, Programs, Hardware, Members list.

TI990 User Group
Simon Garth, 8 Kestrel Place, St. Neots, Huntingdon, Cambs.

Bywood Scrumpi User Group
66 Ebberns Road, Hemel Hempstead, Herts HP3 9QRC
0442–62757

UK Apple Users Group
Dr Tim Keen, 5 The Poultry, Nottingham
Nottingham 583254/5/6
:£5:

Research Machines Users Group
PO Box 75, 209 Cowley Road, Oxford
0865–49792

MK14, SC/MP Users Club
Mr G Phillips, 8 Poolsford Road, London NW9

PDP/LSI 11 User Group
P Harris, 119 Carpenters Way, Potters Bar, Herts

PDP 8 User Group
Nigel Dunn, 21 Campion Road, Widmer End, High Wycombe

IM6100 User Group
S P Fiala, 95 Felmongers, Harlow, Essex CM20 3DL

6502 Users Working Party
W R Wallenborn, 21 Argyll Avenue, Luton LU3 1EG
0582–2697 evenings
33:

6800 User Group
Eric Stancliffe, 4 Withensfield, Wallasey, Merseyside
L45 7NP
051–709–6022

Ithaca S100 User Group
Dave Weaver, 16 Etive Place, Condorrat, Combernauld by Glasgow, Scotland
Sae for details

Regional Groups

CAMBRIDGESHIRE
Cambridge University Processor Group
Emrys Williams, Cavendish Laboratory, Downing College, Cambridge

DEVON
Exeter and District Amateur Computer Club
David Carne, 44 George Street, Exmouth, Devon EX8 1LQ
03952–74479
65:Tu Fort:£5,25p Stud:Newsletter,Workshops.

South West Group Amateur Computer Club
G V Barbier, Palmers Hill, Calverleigh, Tiverton, Devon

BRISTOL
Brunel Technical College Computing Club
S Rabone, Electrical and Electronic Engineering Department, Brunel Technical College, Bristol

Bristol Amateur Computing Club
Rex Godby, 16 Williamson Road, Ashley Down, Bristol BS7 9BH
Bristol 46981

Bristol Computing Club
Mr L Wallace, 6 Kilbernie Road, Bridge Farm Estate, Bristol BS14 0HY
:W3:

WALES
Gwent Amateur Computing Club
Pete Hesketh
Shire Newton 596

ESSEX
Colchester Amateur Computing Club
Donald Clarke, 21 The Avenue, Colchester, Essex CO3 3PA
Colchester 66637

GLOUCESTERSHIRE
Cheltenham Amateur Computer Club
M P Pullin, 45 Merestones Drive, The Park, Cheltenham
Cheltenham 25617

HAMPSHIRE
Southampton University Amateur Computer Club
c/o Mr P G Doney, School of Bio Chem & Physio Sc., University of Southampton

KENT
Gillingham User Group
A Aylward, 194 Balmoral Road, Gillingham, Kent
Medway 56830

Bromley and Orpington
Phil Wheeler, 1 Irene Road, Orpington, Kent
Orpington 23800

Sittingbourne
J M Baron, 27 Wises Lane, Borden, Sittingbourne, Kent
Sittingbourne 70160

LIVERPOOL
Liverpool University
Malcolm Taylor
051–709–6022 extn 2955

Merseyside Microcomputer Group
Mr John Stout, Department of Architecture, Liverpool Polytechnic
:£2, £1 student:

DORSET
Bournemouth and Poole Area Computer Club
Mr Ian Preece, 246 Stewart Road, Charminster, Bournemouth, Dorset

TYNE AND WEAR
Newcastle Personal Computer Society
Dr W G Allen, Department of Electrical Engineering and Physical Electronics, Newcastle Upon Tyne Polytechnic, Ellison Place, Newcastle Upon Tyne NE1 8ST

LONDON
North London Hobby Computer Club
The Secretary, c/o Dept of Electronics, Polytechnic of North London, Holloway Road, London N7 8DB
01–607–2789 ext 2162 afternoons
320:W1:£10,inc course,£2.50 students:Courses,Newsletters, Workshops,Sub Groups.

Southeast London Microcomputer Club
Don Hicks, Breakspears Road, Lewisham Way, SE4 1UT
01–692–0353 extn 358
:W3:

East London Amateur Computer Club
Jim Turner, 63 Millais Road, London E11
:Tu3:

Southgate Technical College Computer Club
Mr I E Williams, c/o Southgate Technical College, High Street, London N14 6BS
Paul Woolley 01–886–6521
35:We1 Th3:£1: :Workshops,Newsletter,Next to Southgate tube.

Eltham Amateur Computer Club
R I Mitchell, 58 Kenilworth Gardens, Shooters Hill, London SE18 3JB
01–856–2489

IRELAND
Computer Education Society of Ireland
7 St Kilmaind, Blackrock, Co Dublin, Eire

Belfast Amateur Computer Club
John Peacocke, 22 Wheatfield Gardens, Belfast 14

NOTTINGHAMSHIRE
Nottingham Amateur Computer Club
Mr Draga, 3 Troutbeck Crescent, Bramcote, Beeston
0602–256622

Nottingham Microcomputer Club
Mr P C McQuoney, 28 Seaford Avenue, Wollaton, Nottingham
:M1:

STAFFORDSHIRE
M J Brough, 11 Beech Drive, Kidsgrove, Stoke on Trent
07816–4387

OXFORDSHIRE
Oxford and District Amateur Microcomputer Club
S C Bird, 139 The Moors, Kidlington, Oxon

SUSSEX
Brighton Amateur Computer Club
P Weaver, 30 Warren Way, Telscombe Cliff, New Haven, East Sussex BN9 7DJ

Sussex Personal Computing Society
N Latchem, 23 Silverdale Road, Hove, Sussex

MANCHESTER
Manchester User Group Amateur Computer Club
P Wade, 26 Wolseley Close, Radcliffe, Manchester M26 0AG
061–723–1021

LANCASHIRE
Northwest Group Amateur Computer Club
Ken Horton, 50 Lymefield Drive, Worsley, Manchester

YORKSHIRE
Bradford Amateur Computer Club
Barry Waite, 315 Toller Lane, Heaton, Bradford 9
Bradford 498750

South Yorkshire Amateur Computer Club
N Beard, High Street, Braithwell, Rotherham

South Yorkshire Personal Computing Group
Tony Rycroft, 88 Spinneyfield, Moorgate, Rotherham, S.Yorkshire
Rotherham 74889 evenings
:W2:£3:

LINCOLNSHIRE
Lincolnshire Microprocessor Society
Michael Lyne, Far End, Far Lane, Coleby, Lincoln LN5 0AH
0522–810468

Lincoln Amateur Computer Club
M Alexander, 5 Brattelby Crescent, Lincoln LN2 2EB
Lincoln 23084

MIDLANDS
Midlands User Group Amateur Computer Club
Roy Diamond, 27 Loweswater Road, Coventry CV3 2HJ
0203–454061

West Midlands Computer Club
Tony Bridgewood
021–557–6709

West Midlands Amateur Computer Club
John Tracey, 100 Booth Close, Crestwood Park, Kingswinford DY6 8SP
0384–70097

MIDDLESEX
Harrow Group Amateur Computer Club
Jim MacDonald, 19 Cowper Road, London W7 1EL

Harrow Local Group
Alan Secker, 209 Olbury Drive, Pinner, Middlesex
01–428–0844

Richmond Computer Club
Mr R A Forster, 18A The Barrons, St Margrets, Twickenham, Middx
01–892–1873
30:M2:£0.15 per meeting: :6800 Library,Richmond Community Centre.

West Drayton RAF Amateur Computer Club
Squadron Leader Harrot
West Drayton 44007 extn 2410

SCOTLAND
Scottish Amateur Computer Club
S Stevenson, Lindisfarne, New Well Wynd, Linlithgow, West Lothian
Linlithgow 2657

Grampian Amateur Computer Society
Mr Michael Brown, 282 Queens Road, Aberdeen AB1 8DR
16:M2:

LEICESTERSHIRE
Leicester Amateur Computer Club
G B Foden, 11 Gaddesby Lane, Rearsby, Leicester
Rearsby 247

BUCKINGHAMSHIRE
High Wycombe User Group
Roy Woodbridge, Department of Engineering, College of Higher Education, High Wycombe

BERKSHIRE
Thames Valley User Group
Dave Howland, 4 Kent Lodge, Courtlands, Maidenhead, Berkshire
0628–36976
:Thl:

ACC Specialist Groups

2650 Library
R A Munt, 51 Beechwood Drive, Feniscowles, Blackburn, Lancashire BB2 5AT
0254–22341

6800 Software Library
Roy Hall, 89 Hicks Avenue, Greenford, Middlesex
01–5798–9136

COSMAC (1802) Library
R C Sheppard, 15 Kinnaird Way, Cambridge

9900 User Group and Library
Simon Garth, 67 De Parys Avenue, Bedford

ACC 8080/Z80 Library
Neil Harrison, 24 Copenhagen Street, London N1 0JD

ACC General Library
Frank Cato, 3 Rykneld Way, Derby DE3 7AT
0332–513769

Small Processor Library
J R Knight, Department of Meteorology, University of Reading, Earley Gate, Whiteknights, Reading RG6 2AG

6800 Hardware Library
Bob Forster, 18A The Barrons, St Margarets, Twickenham, Middlesex
01–892–1873

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....

....

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Name ....

Address ....

....

Please allow up to 28 days for delivery

Mr John R. Welty (Motorola Semiconductors)

Discretes Rule OK?

Ever since the development of the integrated circuit back in the mid-1959s, a recurrent theme in our in our industry related to the impending demise of the discrete semiconductor business. The press, some of our friends in the financial community, and many other observers of the semi-conductor scene, have often tended to downplay the importance of discrete components in the future of the industry. The usual scenario drawn by these observers called for the discrete industry curve to generally flatten during the 1970s — continue on a descent throughout the 1980s — and almost fall completely off the industry charts by the 1990s.

The primary reason for this somewhat gloomy outlook, of course, was the phenomenally rapid growth of the IC technology, in which a steadily growing number of discretes were and are, being integrated into the silicon chip and losing their identity as discrete components. As you know, the integrated circuit technology advanced, in a relatively short period of time, from devices containing 10 or 15 transistors to the current situation in which they contain thirty or forty thousand transistors in the same sized silicon chip. And, there certainly isn't any doubt that the number will escalate to the hundreds of thousands by the early 1980s, and to perhaps a million per chip by 1985 or so.

The advent of the microprocessor, and the rosy future that all of us in the industry are predicting for it, has no doubt tended to compound the "image" problem that exists within the discrete component industry.

Changing Society

The microprocessor has been the most publicised product ever developed by the semiconductor industry, and perhaps rightly so. I honestly believe that the microprocessor will eventually be recorded in history as one of the most important, if not THE most important, industrial development of the twentieth century.

The amount of change, and the speed of change, that the microprocessor will bring to the worldwide social, political and industrial institutions during the next decade will stagger even the most fertile of imaginations. The number of new or improved electronic products for the home, the automobile, the factory, the office, the school, the government and the military organizations not only in the U.S., but around the world, will number in the thousands. And that will only be the beginning, we will barely have scratched the surface of what can be accomplished through the microcomputing technology.

The rapidly growing volumes of microprocessors being used are, to a large degree, responsible for our predictions that the U.S. semi-conductor industry will double its present size in the next four or five years. Another reason, less dramatic perhaps than the growth in microprocessors, is the quiet but significant revolution that the MPU technology is creating within the discrete component industry.

It is estimated that more than 50 per cent of the microprocessors being produced today are for new product applications which previously were not feasible for either technical or financial reasons. While these new microprocessors are having somewhat of a negative impact on conventional standard logic integrated circuit families, their impact on discrete components is definitely positive. Microprocessors cannot function by themselves. Depending on the application, a number of different types of discretes are required for rectification, for voltage regulation, for power handling and for carrying out the actions determined and ordered by the microprocessor.

What Of Discretes?

Before I get more deeply involved in the subject of MPU-related discrete components, I would first like to spend a few minutes on the industry's outlook for the discrete component business in general.

In the fall of 1978, in my capacity as chairman of the Semiconductor Industry Association, I had the opportunity to unveil our industry outlook at the association's annual forecast meeting in Palo Alto.

I'd like to share with you the data we presented regarding our consensus view of the next three years for the discrete component business.

(Figure 1) This chart depicts the worldwide sales of discrete components by U.S.-based semiconductor manufacturers between 1977 and 1981. No foreign manufacturers are included, and the data is presented in both current dollars and annual growth percentages.

Several points are worthy of note. First of all, we believe that industry sales will grow to slightly more than 1.5 billion dollars this year, up nearly twelve per cent from the 1977 level, which was essentially flat with the previous year.

By 1981, the industry sales are expected to climb to approximately 1.75 billion dollars, an increase of nearly a quarter of a billion dollars. During the four-year period — from 1978 through 1981 — we expect compound growth rate for discrete components of about six per cent.

The change in product mix is a little less obvious. Small signal transistors, for example, was the largest selling product line last year; the second largest seller this year, and by 1981 we find it relegated to third place — and almost a fourth place — position. This is, of course, due to the fact that small signal transistors are most vulnerable to integration.

In all other major discrete product lines we anticipate varying levels of growth. If you compare the actual 1977 sales with the anticipated 1981 sales, you can see that we anticipate modest growth for diodes, and rather dramatic growth for power transistors, rectifiers, thyristors and optoelectronics. It is precisely these four product lines whose growth will be effected, in a very positive sense, by the emerging microprocessor technology.

Current Dollars in Millions	1977	1978	1979	1980	1981
Diodes	167	178	169	174	176
Small Signal Transistors	318	317	304	302	300
Power Transistors	313	347	359	375	407
Rectifiers	226	271	271	289	309
Thyristors	146	158	159	173	189
Optoelectronics	155	209	228	260	285
All Other Discretes	68	78	77	82	87
Total Worldwide	1394	1558	1567	1655	1753

Annual Growth in Percent	1977	1978	1979	1980	1981
Diodes	0	6.6	−5.0	2.9	1.1
Small Signal Transistors	1.9	0	−4.1	0	0
Power Transistors	1.3	10.8	3.5	4.5	8.5
Rectifiers	1.3	19.9	0	6.6	6.9
Thyristors	22.7	8.2	0.6	8.8	9.2
Optoelectronics	−21.7	34.8	9.1	14.0	9.6
All Other Discretes	−5.6	14.7	−1.3	6.5	6.1
Total Worldwide	0.5	11.8	0.6	5.6	5.9

Fig. 1. Discrete product forecast by major product category.

In next year's forecast, when we add a 1982 column, and the following year, when we add the 1983 forecast, I think the comparisons will be even far more startling than they are right now, because the 1981 forecast reflects just the onset of high-volume microprocessor applications.

Growth

Figure 2 shows the growth we anticipate for all MPU-related discrete products. As in the charts that will follow, this is a relative growth chart, with 1978 unit sales being equal to one.

It's easy to see that we anticipate the most MPU-related growth being enjoyed by rectifiers and power transistors. Both of these product lines begin to take off from their already high level during 1979, and by 1981 their sales will be about three and one half times their current level. Zener diodes and small signal transistors will be nearly three times their present level, while optoelectronics and thyristors will increase just slightly. This graph has even more impact if you'll recall that Fig. 1 indicated that power transistors became the largest selling discrete line this year and rectifiers are in the number three position. The growth of these two product lines alone for MPU-related applications will account for a large percentage of the total discrete industry growth between this year and 1983.

In the next two figures, I have segregated this same data into automotive and non-automotive microprocessor-related applications. I did this to dispel any notion that the anticipated MPU-related discrete growth is entirely due to the widely publicized, high-volume automotive applications

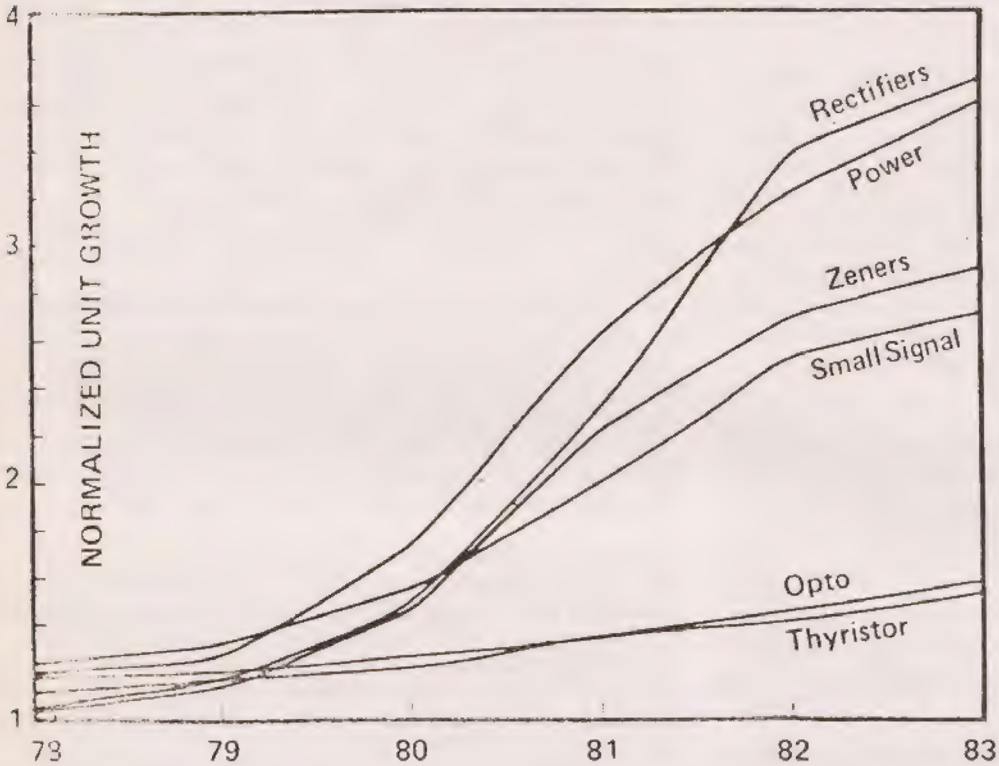


Fig. 2. 1978-83 growth trends, total MPU-related discretes.

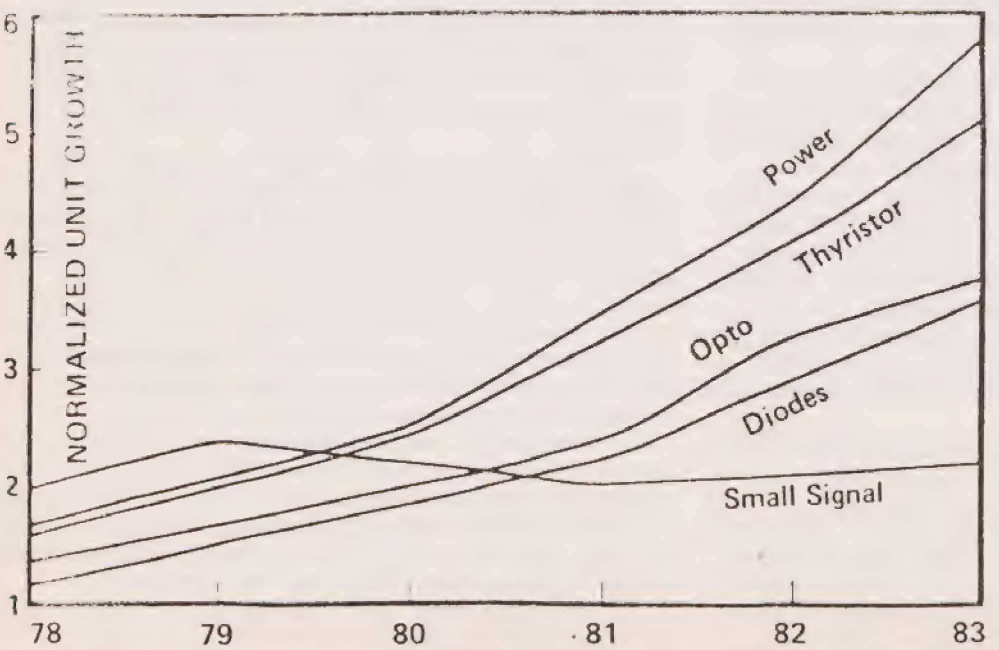


Fig. 3. 1978-83 growth trends, non-automotive MPU-related discretes.

that loom on our horizon. Automotive applications will certainly be the major cause of the discrete growth, but non-automotive MPU applications will also be very respectable.

Non-automotive

Figure 3 shows how the data looks without the automotive applications. Power transistors and thyristors are the leaders in this case, more than doubling their current MPU-related applications. Optoelectronics and diodes, starting from a lower base, will triple their present usage in MPU applications, while small signal transistors will remain relatively flat.

The markets most impacted by these new MPU and discrete combinations are the computer, industrial and consumer sectors, in reverse order of their importance.

Computers

While the computer applications will be large and varied, they will be less spectacular than either the industrial or consumer applications. The main product areas in which discrete usage will increase because of MPU applications are rigid discs, electrostatic printers, line printers, matrix printers, floppy-disc systems and both CRT monitor and keyboard terminal systems. A wide variety of discretes will be used to drive hammers in MPU-controlled printers, to position heads in MPU-controlled disc memory systems, and in the horizontal and vertical circuits for CRT monitors, as well as in the power supplies of most computer products.

Industrial

In the industrial market, the volume and variety of discrete MPU-related applications will be greater than they are in the computer market. The most obvious usage will be in automated process control and production equipment. Everything from making steel to McDonald hamburgers will be improved, in terms of speed and precision, by the microprocessor technology. Again, a variety of discretes will be required to handle the power and carry out the orders of the MPU. While it's impossible to peg a precise discrete usage number for these applications, they will certainly be used by the tens of millions each year.

There are several other industrial applications I would like to mention briefly, because they are interesting and possess the potential for extremely high discrete component usage.

The first is in the area of large displays, such as the animated sign boards that are beginning to appear in our major sport stadiums. The display technology is quickly evolving, and I think we will see a proliferation of this type of equipment over the next few years, not only for sporting events, but in promotional and advertising signs of every size and description. The potential for discretes here is very large. Some of the current sports displays, for example, already contain as many as 60,000 thyristors or power transistors alone. In addition, a great number of discretes are already being used in the associated power supply systems. Again, this is a market that will probably require millions of discrete devices each year.

Another important industrial market that is on the verge of explosion is the entire field of energy management. Because of the nationwide concern for energy conservation, various states are beginning to legislate "time of day" or "demand" measurements of energy usage to allow for higher charges during peak load periods. As this legislative movement gains momentum, we will see the emergence of many different types of energy management systems. One of the first to appear will be a new generation of electric meters that will employ the MPU technology as well as a number of discrete components. Other energy management systems will soon follow, and they will all use discretes as well as microprocessors. The potential for thyristors alone in this newly emerging market over the next five years should be well in excess of 15 million units.

Traffic control is another newly emerging market for discretes, again because of the application of microprocessors in traffic signals. In the past, conventional logic such as HTL or CMOS have been used in such signals, but the number of MPU-controlled signals is growing readily. This, in turn, will greatly increase the usage of opto-couplers and thyristors in such applications.

Another very important area, in which a dramatic shift in the technological make-up of the industry will result in significant growth potential for discretes is in telecommunications. The present shift from electromechanical to digital switching is the result of the tremendous cost effectiveness of MPUs and the associated, dedicated LSI devices. This development is again increasing the demand for discrete components, particularly power transistors and bridge rectifiers. The accumulated potential for these discretes in switching alone should be greater than 15 million dollars during the next five-year period.

Discrete usage in telecommunications will also be enhanced as the new fibre optic transmission techniques become refined and applied. The potential for emitters and detectors in this area alone is in the neightbourhood of another 15 million dollars over the next five years.

While the computer and industrial applications are diverse and growing, some of the most exciting potential lies in the consumer segment of the discrete market.

Consumers – Watch Out!

The home appliance market is a good example. Microprocessors will be used in huge and steadily growing numbers in washers and dryers, refrigerators, dish washers and microwave ovens. An even greater number of discretes will be required. The MPU-controlled electronic system will replace the mechanical clocks and cams in order to provide more effective control and flexibility to the user. In most of these major appliances, four to eight thyristors will be required. In addition, opto-couplers will be required to isolate the electronics from the rest of the appliance in order to reduce the potential of electrical shock and provide the high levels of product safety being required by present government legislation.

The security systems market is another new and rapidly emerging business that holds great potential for additional discrete usage. A popular political slogan of the past was "A chicken in every pot." The slogan of the future appears to be "A security system in every home." This market is on the verge of tremendous growth, and I suspect that at some point in the future every new home will come equipped with a sophisticated security system. While these systems will be MPU-controlled, a great number of discrete will be required to actuate the alarms and indicators.

There are a number of other emerging consumer markets that bode well for increased discrete component usage. MPU-controlled video games . . . electronic TV tuning . . . and home environmental control systems . . . to name just a few. All of these new, MPU-generated product developments will require discrete components each year.

Now let's turn our attention to the automotive applications for MPU-related discretes.

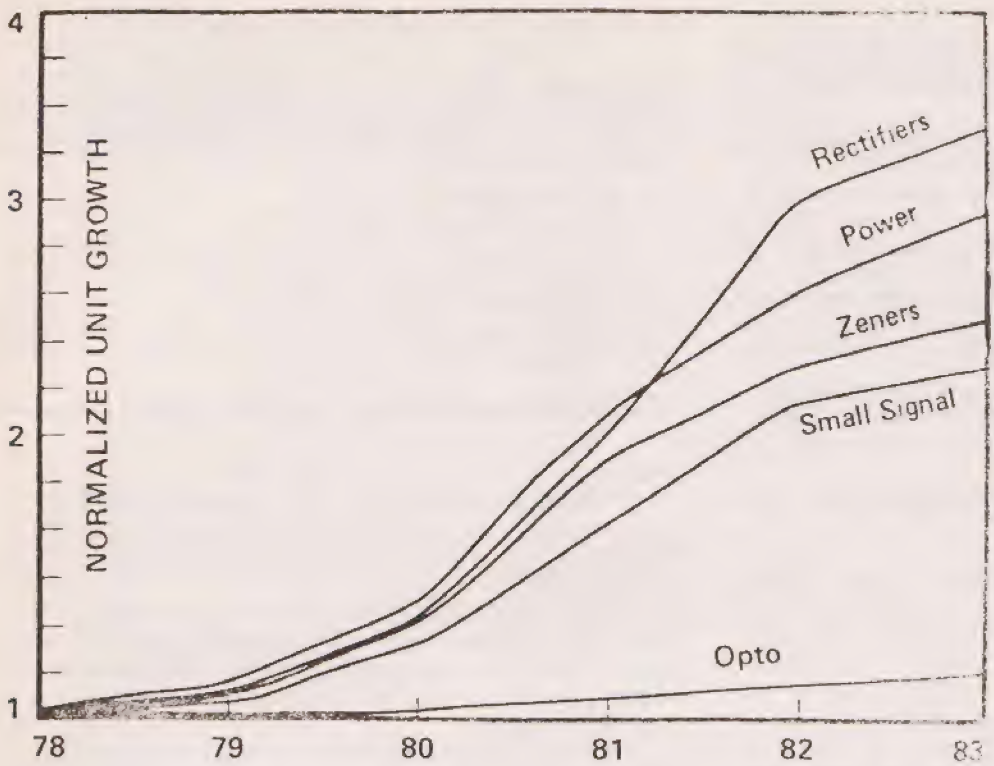


Fig. 4. 1978-83 growth trends, automotive MPU-related discretes.

Automotive Uses

Figure 4 shows the relative growth trends for the major discrete product lines in automotive applications. While opto-electronics will grow slightly, major growth will be recorded by the four others: rectifiers, power transistors, zener diodes and small signal transistors.

While the initial application of microprocessors to automobiles has created a great deal of excitement in the marketplace, there is a great deal yet to come.

In their current application, which extends through the next two or three model years, MPU's are being used primarily in ignition control systems. After collecting data on such things as speed, temperature, humidity and altitude, the microprocessor automatically adjusts the carburation, spark and timing. In effect, it tunes the car while it is being driven. This application is the auto industry's first step in meeting the government-mandated challenges to reduce emissions, improve safety and increase fuel efficiency.

The engine control systems of the future will add a pre-ignition system to the vehicle, primarily for the purpose of knock detection. Also, such things as oxygen sensors will be added to the exhaust system to monitor the efficiency of the combustion. This information will then be fed back through a microprocessor which would further adjust the carburation, if required.

Another future MPU application in autos is in the area of load management, or more simply put, transmission control. Transmissions of the future will not include definite gears such as first, second, or third. Instead, they will have an MPU-controlled servo-mechanism that will automatically adjust itself according to the load the vehicle is being required to carry. As a result, the proper gear ratios will always be chosen to maintain optimum torque efficiency and maximum engine efficiency.

Another interesting application which is down the road a bit will be in levelling systems. Federal regulations are already requiring that all bumpers be a certain distance from the ground in order to minimize the damage from impact. To accomplish this, bumpers either have to be very wide to take into account bumper height changes brought about by acceleration and deceleration, or systems need to be developed to keep bumper height constant at all times. Such systems are already under development, using Hall effect sensors to detect uneven loading or levelling situations. The detected data is then coupled back to a microprocessor, which, in turn, drives an actuator which self-corrects or compensates for the uneven loading. In all cases, the actuators would be driven by discrete devices, most likely power transistors or thyristors.

There are also a number of other new automotive applications for discretes that are indirectly related to the MPU applications. The emergence of the one-wire electrical system utilizing fibre optics seems to be a distinct possibility. This, in turn, would create brand new markets for such things as opto-couplers and other discretes. New types of digital dashboard displays will also provide new liquid crystal applications sometime in the future.

These are just a few examples, but I think they illustrate the reason for our confidence for the steadily increasing penetration of discretes in the automotive market. This year, total discrete sales for automotive applications amounts to about $3.80 per car. By 1982 or 1983, that amount will grow to about $11.50 per car. The difference — about $8 — will be almost entirely created by the variety of new, MPU-related applications. In addition, nearly $6 of that $8 growth will be in engine control systems.

Who Says Discretes Dead?

Perhaps these reliable workhorses of the industry have less glamour, and receive less publicity, than some of our more exotic LSI developments, but they provide an extremely critical link between the feasibility of exotic integrated circuits and their actual implementation. Discretes are alive and well and growing, and such will be the case for many years to come.

Dear Sir,

I read with interest the article on M5 in the May issue of Computing Today. Mr Bell had obviously studied the language very closely and with great skill.

The modifications he suggests to increase program space may be useful, and if variables need not be kept between programs, a "clear screen" before execution is an aid to clarity.

Mr Bell may however be pleased to learn that the ">" and "<" characters are available on NASCOMs with T1 and T2 monitors. They can be obtained by "SHIFT ." and "SHIFT ," with T2 or "SHIFT N" and "SHIFT M" with T3, and they look clearer when used in an edit line.

M6 will reside in a 1K ROM, and contain subroutine facilities, character handling, array manipulation, tape dump and load, with various other useful functions and a more powerful editor.

The lunar lander program is very impressive, and takes some time to learn to fly.

Yours sincerely,
Raymond Anderson

A29 Harvey Court,
West Road,
Cambridge.

Dear Sir,

I was most interested to hear about the M5 language, which is obviously a close relative of the programmable calculator keystroke languages. I thought Mr Bell failed to point out some of the obvious advantages of such languages which can be made as powerful as any BASIC. If Mr Bell doubts this I suggest he try a HP9815. I don't pretend that such a machine is good value for money, but I think the software is excellent and easy to learn and use. The advantages of this sort of language are:

1) The interpreter is much smaller than the equivalent BASIC interpreter. The M5 is shorter than many monitors and most assemblers. Equally obvious is that a 2K or 4K keystroke language can be very much more powerful than the BASIC interpreter in the same space.

2) Programs take much less space. For instance the first two lines of the lunar lander program shown contain 48 characters compared with BASIC source code which requires about 98 (3 fig line numbers).

3) You can get useful hard copy of a program in keystore language with as few as 12 characters per line (eg PC100A for TI calculators). This makes for a much cheaper system.

4) Keystroke languages have inherently simple syntax and this fewer errors (syntactical).

There are two ways of looking at microcomputer systems. One is to ape mini and larger computers and have mini floppy discs, mini BASIC, mini modules. This is incidentally good business for the manufacturers because they can always lure you up the scale.

The other way is to make micro systems into super calculators. By that I do not mean that they necessarily should all be number crunchers, but to be calculator like plus more memory, peripheral interfacing, mass storage, etc.

Incidentally, why have I never seen a cassette tape system which can be run forwards and backwards, fast and normal, under program control? (see HP9815 again) Such a system, would, I suspect, dent sales of floppies due to its very much lower price.

Yours sincerely,
Nigel Falden.

Bright's Farm,
Bramfield,
Haleworth,
Suffolk.

Dear sirs,

Having read A.R.Ingleson's comments in the May issue regarding bad etching and faulty components in the "Nascom I" kit, I am glad that I decided in favour of the "Triton" kit.

The printed circuit board was first class and the only problem with components was a few weeks delay on some of the chips. This system did work first time, and as this was my first attempt at constructing anything electronic, I am very pleased.

Your 'Softspot Special' section is a very good idea. Long may it continue.

Yours faithfully,
G.A.Slyfield.

29 Helston Road,
Springfield,
Chelmsford,
Essex.

Dear Sir,

I cannot let the letter from Mr. Ingleson pass without a reply in defence of the Nascom kit. It is true that I didn't actually get my kit up and running first go. I found I had a most peculiar repeating column effect on the display. I traced this to a single pin I had failed to solder on the screen driving chain of I.C.'s. A moments work with the soldering ireon and – magic!

I had assembled one other smaller kit before. In comparison with that I found the Nascom construction manual most helpful and detailed, and most explicit on the silly things that cause all the real trouble, like which way round all the components go. No trouble with the cassette interface. I'm now using T-4, which gives a faster rate also, and the 'generate' command is rather nice.

The construction manual does point out that to build a Nascom you have to solder some 1300 joints, and advises you not to hurry. I did build the system slowly, and it worked!

Yours faithfully,
T.M.Spence.

23 Thorburn Road,
Edinburgh EH13 0BH.

HANOI TOWER

Ray Anderson

This program runs on a standard Nascom 1. Its purpose is to give instructions to a person trying to solve the "Towers of Hanoi" puzzle. The puzzle is in the form of three rods and a set of different sized discs, which fit on the rods. The object is to move the discs from tower A to tower C, one at a time, while ensuring that after each move of a disc between towers, no disc is placed over a disc smaller than itself. The discs start on tower A. Every time a key is pressed, the correct move to make next will be displayed. When the transfer is complete, the monitor is re-entered.

```
                 ;
                 ; Program to Give directions for
                 ; the Towers of Hanoi, showing
                 ; how recursion can be used.
                 ;
013B             CRT    EQU 013BH ; Nascom Routine.
003E             CHIN   EQU 003EH ; Returns when key pressed.
0286             PARSE  EQU 0286H ; Nasbug re-entry.
                 ;
001F             CRET   EQU 1FH   ; Nascom Newline.
                 ;
0C60             ORG    0C60H
                 ;
0C60 EF44697363  START  DB 0EFH,'Discs?',0
0C65 733F00
0C68 CD3E00      LOOP   CALL CHIN
0C6B D630               SUB '0'   ; Make a number.
0C6D FE09               CP  9     ; IF too high
0C6F 30F7               JR NC,LOOP-$ ; try again!
0C71 47                 LD B,A
0C72 C630               ADD A,'0'
0C74 CD3B01             CALL CRT
0C77 0E41               LD C,'A' ; On entry to MOVE, C contains "from"
0C79 1643               LD D,'C' ; tower, D contains "to" tower, and
0C7B 1E42               LD E,'B' ; E contains spare tower.
0C7D CD830C             CALL MOVE
0C80 C38602             JP PARSE
                 ;
0C83 78          MOVE   LD A,B    ; Routine tells what
0C84 A7                 AND A     ; moves for B discs
0C85 C8                 RET Z     ; unless B=0
0C86 C5                 PUSH BC
0C87 D5                 PUSH DE
0C88 05                 DEC B
0C89 7B                 LD A,E  ; Swop about registers.
0C8A 5A                 LD E,D
0C8B 57                 LD D,A
0C8C CD830C             CALL MOVE ; Try moving B-1
0C8F CD9C0C             CALL SHOW ; Show what to move
0C92 79                 LD A,C  ; Swop registers again
0C93 4A                 LD C,D
0C94 53                 LD D,E
0C95 5F                 LD E,A
0C96 CD830C             CALL MOVE
0C99 D1                 POP DE
0C9A C1                 POP BC
0C9B C9                 RET
                 ;
0C9C EF1F4D6F76  SHOW   DB 0EFH,CRET,'Move disc ',0
0CA1 6520646973
0CA6 632000
0CA9 78                 LD A,B
0CAA C631               ADD A,'1'
0CAC CD3B01             CALL CRT ; Display B
0CAF EF2066726F         DB 0EFH,' from ',0
0CB4 6D2000
0CB7 79                 LD A,C
0CB8 CD3B01             CALL CRT
0CBB EF20746F20         DB 0EFH,' to ',0
0CC0 00
0CC1 7B                 LD A,E
0CC2 CD3B01             CALL CRT
0CC5 C33E00             JP CHIN ; Wait for a key before
                                ; continuing with next move
                                ; via return from chin.
                  END
```

Mr P. Cornes

This month Phil Cornes takes a look at extended BASIC

Up to now, all the facilities we have described should be found on any machine that can run any form of BASIC. Unfortunately, Extended BASIC is not so cut and dried. Different manufacturers tend to have different ideas on the facilities that should be provided, and they tend to pick some facilities because they highlight some of the best points of their machines.

Having said this, however, there are still plenty of facilities common to most machines: just don't be too upset if we describe a facility your machine doesn't have, or miss a facility it does have.

When we first started the series, we took a look at the meaning of words like variable, and operator. We are going to go back and look at these again now, as their scope has been broadened somewhat with the introduction of Extended BASIC

Variables

The first thing to note about Extended BASIC is that the number of variable names increases somewhat. Whereas in Tiny BASIC we had 26 variable names, A-Z, and one single subscript variable, A(X) or @(X), in Extended BASIC we have many more. Typically these include –

1. The letters A–Z:
2. Any letter followed by a single digit 0–9 (eg A1, S5, Z9 etc. where A1 is totally distinct from A(1) and so on);
3. Many BASIC versions also include combinations of two or more letters (eg ZQ, PT, ID etc.);
4. In addition to this, any common variable name (T, B4, PR etc.) may also be made into a subscripted variable of the form T(X), B4(X), PR(X) etc.
5. String variables of the form any common variable name followed by a $ sign (eg B$, C8$, ST$ etc).

The first three types of variable name (common variables) listed above are quite straight forward. They are just an extension of Tiny BASIC's 26 variable names A-Z, but the other types of variable will require a little more discussion.

Subscript Variables

In Tiny BASIC we had A(X) where X could take any value from 1 to a value determined by the amount of free memory space available. Since we were only allowed one such variable, we did not need to inform the computer how many elements of this array we were going to use because the computer would keep accepting the values we assigned to the various elements of the array until it ran out of free memory space and informed us of this fact.

In Extended BASIC, there are endless numbers of possible Subscript variable names and the computer has to allocate a known amount of memory to each one that appears in a program. This means that we now have to tell the computer how many elements will be used for each subscript variable. We do this by means of a new statement.

DIM

No! This is not to tell the computer that we think it is thick. DIM is an abbreviation for the word DIMension where the word is used to mean size in this context. The following is an example of its use :–

```
10 DIM Q(4)
```

This tells the computer to reserve memory space for 5 elements to be labelled Q(0), Q(1), Q(2), Q(3) and Q(4).

It is possible to dimension several variables in a single DIM statement, as follows:–

```
30 DIM B4(3), AD(7), R(19)
```

This statement is telling the computer to reserve space for 32 subscript variable elements all together (don't forget we also include zero subscripted elements (B4(0) etc.) now).

In Tiny BASIC our subscript variable only had one DIMension. Just to confuse you, one dimension here means that there was only one number in the bracket to specify which element we were refering to. In Extended BASIC, we can have subscripted variables in more than one dimension.

```
56 DIM D(3,2)
```

tells the computer to reserve memory space for the D array which has double subscripts 0–3 and 0–2 (12 elements in all). You can imagine this to be a two dimensional matrix set out as follows.

D(3,0)	D(3,1)	D(3,2)
D(2,0)	D(2,1)	D(2,2)

D(1,0)	D(1,1)	D(1,2)
D(0,0)	D(0,1)	D(0,2)

Some versions of BASIC will allow more than two dimensions, e.g.

```
71 DIM GT(3,7,6,4)
```

contains four dimensions. Indeed I have seen one version of BASIC which will allow 9 or 10 dimensions (heaven knows what you would do with them all!).

Consider the following:—

```
10 DIM A(3,2), V(2)
20 V(0)=0
30 V(1)=8
40 V(2)=12.5
50 FOR X=0 TO 3
60 READ PR
70 FOR Y=0 TO 2
80 A(X,Y)=PR+PR*V(Y)/100
90 NEXT Y
100 NEXT X
110 DATA 520,630,704,931
120 END
```

This program is calculating VAT at the three different rates, 0%, 8% and 12.5%, on the prices of items listed in the DATA statement of line 110. The three VAT reates are stored in the V array, [V(0) to V(2)] by lines 20 to 40.

Each price in line 110 then has VAT added to it by line 80. All the answers are stored in the A array, a two dimensional array. Each of the columns in this array stores the three prices, one for each VAT rate, and each row stores the price of each of the four items at a single VAT rate.

String Variables

This is a totally new kind of variable and one that we shall spend much time discussing as there are many facilities associated with it.

Just as a common numeric variable (A,XZ etc.) can be assigned a value which can then be manipulated and used in calculations and decisions, so can a string variable be assigned a value which can be used similarly. The main difference is that a string variable doesn't have to consist of digits but can consist of any string of characters that are available on the keyboard (usually with three exceptions — comma, inverted commas and carriage return). Eg:—

```
10 A$ = "THIS IS THE STRING CALLED A$"
```

In this example, the computer will assign to the variable A$ the value

THIS IS THE STRING CALLED A$

note that the inverted commas are not assigned to A$. They are used by the computer to show where the string begins and ends.

As with any other variable, the statement -

```
30 PRINT A$
```

would cause the above message (minus inverted commas) to appear on the output peripheral.

Consider the following —

```
5 PRINT "INPUT YOUR NAME";
10 INPUT A$
20 IF A$ = "PHIL" THEN 50
30 PRINT A$; "IS NOT ACCEPTABLE — PROGRAM
   ENDED"
40 END
50 PRINT "HI PHIL — WHAT'S ON TODAY"
60 . . . . . . .
70 . . . . . . .
```

Here we see two more examples of string variables being used in the same way as numeric variables can be used.

Line 5 asks you to INPUT YOUR NAME. Line 10 will assign any string of characters you input to A$. You do not need to input inverted commas here as the computer knows where your input string starts and ends. Line 20 checks your input string for a particular combination of characters (in this case PHIL) and if this combination is found, the program branches to line 50 and continues.

If your input string is not the particular combination being considered then the program terminates in line 40 after printing an error message in line 30.

It would have been quite acceptable to use any relational operator (=,>,<,>,<=,<>) instead of the = sign in line 20. For example, suppose we had used =, what would this mean? In ASCII code (the most popular computer code) every character is given a 7 bit binary number, as its representation, so that —

A in ASCII is 1000001
B is 1000010
C is 1000011 etc.

in ascending binary order, so when the computer is faced with —

```
20 IF A$> = "PHIL" THEN 50
```

then it will compare the first character of the word PHIL (P=1010000 ASCII) with the first character of A$. If the ASCII for the first character of A$ is less than 1010000 then the test fails. If the ASCII for the first character of A$ is greater than 1010000 the test succeeds. If the two ASCII codes are equal, then the computer knows that the two words have the same first letter. It does not know the relationship between subsequent letters, and so these have to be checked — second letter of A$ with second letter of "PHIL" etc — until the test fails with one of the letters of A$ being less than one of the letters of PHIL, or passes with one of the letters of A$ being greater than one of the letters of PHIL, or passes with all of the letters of A$ being the same as all the letters of PHIL. Therefore, if —

A$ = "PHI" the test will fail (A$<PHIL)
A$ = "PHIL" the test will pass (A$ = PHIL)
A$ = "PHILIP" the test will pass (A$> PHIL)

PHI<PHIL because the letter L in PHIL will be compared with the fourth letter of PHI which is a NUL character, which has ASCII code 0000000 and is therefore the least of the ASCII codes (the same reason applies as to why PHIL< PHILIP)

We will now make a start on some of the string functions available in Extended BASIC.

MID $ (STRING,S,L)

It would be most useful if it were possible to extract characters at will from within a string so that they could be tested or manipulated separately (we will see an example of this later) and, indeed, it can be done using the MID $ string function.

Consider the following –

```
10 A$ = "STRING"
20 B$ = MID$(A$,3,4)
30 PRINT B$
40 END
```

the output from this program would be the word RING.

The MID$ function tells the computer to return a substring of the specified STRING variable (here A$) starting at position S (here 3) and containing L characters (here 4).

The word STRING in the heading above may be replaced with any string variable name or string expression, and the variables S and L may be any numeric constant, variable name or numeric expression.

The following is a short program which reads a string of characters from a data statement and searches through it to find the start position of a three-character sub string which is also contained in the DATA statement.

```
10 READ A$, B$
20 L=3
30 S=1
40 T$=MID$(A$,S,L)
50 IF T$=B$ THEN 80
60 S=S+1
70 GOTO 40
80 PRINT B$;"STARTS AT POSITION";S;"OF";A$
90 DATA "EDUCATION","CAT"
100 END
```

If this program were run, its output would be

CAT STARTS AT POSITION 4 OF EDUCATION

Just for practice, look through this program and see if you can see how it works.

Before we finish for this month, we will look at just one more of the string functions available to Extended Basic because you will need it for this month's homework.

LEN (STRING)

The LEN function returns a numeric value equal to the length of the string in the brackets, so that –

```
10 A$ = "PHIL"
20 L = LEN(A$)
```

would assign a value of 4 to L. Similarly, we could have said –

```
20 L=LEN("PHIL")
```

and L would have taken the same value.

This Month's Homework

There is an old saying which says that you should only eat pork in months whose name contains the letter R. So you could eat PORK in MaRch or SeptembeR, but not in May or June.

For homework this month try to write a program which will ask for name of a month to be input, accept an answer as a string, and then search through the input, character by character, looking for an R. If an R is found, a message telling you that you may eat pork in this month should be printed. If no R is found, the opposite message should be output. So if the input was APRIL, the output would be, YOU CAN EAT PORK IN APRIL etc.

Test your program to make sure that it works by using the following test input data.

1) MAY
2) OCTOBER
3) MARCH
4) ENGLAND

Next month we shall go on to examine some more string functions.

Mr A.P. Stephenson

MOTOROLA D2

This month we continue the 6800 programming course and develop your expertise

The Motorola D2 development kit.

After last months introductory article on the D2 programming course we continue with another set of programs. These are aimed at using more of the various facilities on the kit and in the 6800 instruction set.

It will be useful to have a copy of last months article to hand for reference purposes while trying out any of these programs.

Program 6	PERFORM ALL OPERATIONS AS SHOWN IN "REMARKS"						
1	0000	8E 00 FF		LDS		#00FF	Set SP
2	3	48		ASL	A		Double A
3	4	78 00 26		ASL		0026	Double (0026)
4	7	53		COM	B		Invert all bits in B
5	8	7F 00 27		CLR		0027	Set all zeros in (0027)
6	B	70 00 28		NEG		0028	Change (0028) to "2s comp
7	E	7A 00 29		DEC		0029	Subtract 1 from (0029)
8	F	06		TAP			Transfer A to CCR
9	0010	3F		SWI			Stop

This program is just to show off some of the tricks programmers get up to.
Line 2 doubles the contents of ACC A by using ASL which shifts the accumulator one place to the left. It is important to realise that this gives the correct answer only if the shift does cause the sign bit to change; ie, providing the result will not exceed +127 decimal.
Line 3 similar to line 2 except that the shifting refers to address 26. Note however that ASL does not allow DIRECT addressing so the operand must be written as 0026.
Line 4 inverts all bits in ACC B by using COM which means "complement" (actually the "ones complement").
Line 6 uses NEG which means change to "twos complement" which in turn will change a positive number into a negative number. Be careful not to confuse COM with NEG.
Line 7 uses DEC, meaning "subtract 1".
Line 8 loads the ACC A into the CCR (Condition Code Register). Strange operation but no doubt useful later on.
The program of course is nonsense and is only included to illustrate some of the way-out instructions so check it out with sample data.

Program 7	USING X TO STORE TWO BYTES IN CONSECUTIVE ADDRESSES						
1	0000	8E 00 FF		LDS		#00FF	
2	3	CE A3 52		LDX		#A352	
3	6	DF 26		STX		26	Stores A3 in (26) and
4	8	3F		SWI			52 in (27)

This program's sole object is to illustrate how to load/store 16 bit registers. Obviously, we can't fill it with a single memory location. In fact the rule is as follows:

The operand quoted "belongs" to the HIGHER-ORDER BYTE of the register.
The LOWER-ORDER BYTE "belongs" to the next higher address.

Line 3 uses STX (Store the Index Register) with the operand 26. This will cause the higher-order byte (X_H) to be stored in address 26 and the lower-order byte (X_L) to be stored in address 27. Thus two adjacent memory locations share the contents of X between them.
Line 2 loads X with data using IMMEDIATE addressing with a four hex-digit operand.

Program 8	CLEAR bits 0, 1, 2 IN (43) AND bits 5, 6, 7 IN (44)						
1	0000	8E 00 FF		LDS		#00FF	
2	3	96 43		LDA	A	43	
3	5	84 F8		AND	A	#F8	
4	7	97 43		STA	A	43	
5	9	96 44		LDA	A	44	
6	B	84 1F		AND	A	#1F	
7	D	97 44		STA	A	44	
8	F	3F		SWI			

This program illustrates the property of the AND instruction to selectively clear (set to zero) bits within a word without harming the other bits. Remember that a bit pattern (called the "MASK"), when "ANDED" into an Accumulator, will cause the result to be zeros wherever zeros appeared in the mask and unchanged wherever ones appeared in the mask. Thus to clear certain bits, work out a suitable mask word on a piece of paper first, just to "test it". This is wise because the AND instruction is a LOGICAL rather than a familiar ARITHMETICAL instruction and it is not easy to visualise mentally which bits in the mask should be ones and which should be zeros. It helps to consider how an AND logic gate behaves.

Line 3 ——— The mask is F8. Why? Because we are to erase bits 0, the least signif. bit as well as bits 1 and bits 2. Thus the correct mask word to AND into the ACC is 1111 1000 which is F8 in hex. Note that we can't AND a mask pattern while the data remains in memory. An LDA must first be used to bring it out into an accumulator. The ANDing can then be done and finally the result can be stored back in memory by using an STA (lines 2, 3 and 4 respectively).

Line 6 ——— The mask is now to be 0001 1111 which is 1F in hex and again the process requires three instructions (lines 5, 6 and 7).

Program 9	SUBROUTINE TO PRODUCE A DELAY. *STARTING ADDRESS ARBITRARY					
*	0040	CE 00 00		LDX	# 0000	
	3	09	LOOP	DEX		
	4	26 FD		BNE	LOOP	
	6	39		RTS		

Note: The starting number in X is called the TIMING PARAMETER which in the above case is 0000. This is the longest delay, about 0.85 seconds, because 2^{16} subtractions must take place before 0000 is again reached.

Mathematics: CLOCK = 614.4 Kilohertz so one clock cycle = 1.63 microseconds. DEX and BNE each take 4 clock cycles so one rev round the loop takes 1.304 X 10^{-5} seconds. Thus total delay of 2^{16} revs = 1.305 X 10^{-5} X 2^{16} = 0.85 seconds.
The shortest delay is when 0001 is in X.

This is a subroutine, not a program, so it is useless trying to run it as it stands. The delay is produced by counting down to zero the number in X; the delay mathematics are fully described in the program text.

Note that a subroutine MUST END WITH RTS (Return from Subroutine), code 39.

Program 10	USING ABOVE SUBROUTINE TO GIVE LONGER DELAY						
1	0000	8E 00 FF		LDS		#00FF	
2	3	86 10		LDA		#10	
3	5	BD 00 40	DELAY	JSR		0040	
4	8	4A		DEC	A		
5	9	#26 FA		BNE		DELAY	
6	B	3F		SWI			

TIMING PARAMETER IN ACCA IS "10" IN THIS EXAMPLE (14 Seconds).

This provides a simple example of the use of a SUBROUTINE, ie, makes use of a block of instructions which can be effectively "spliced" into a program by simply knowing whereabouts in memory it is stored and jumping to it with the instruction JSR (Jump to Subroutine). When the subroutine instructions have been executed, its LAST instruction automatically returns control back to the program again. The return (which may be to a different address each time it is used) is ensured by using the instruction RTS (Return from Subroutine) which must be the LAST instruction in the subroutine. How does the RTS instruction "know" where to return? This is where the STACK comes in. The mechanism is as follows;

a. When JSR is used in the program, the computer automatically dumps all the registers in the stack including the PROGRAM COUNTER (which is always pointing to the NEXT INSTRUCTION to be executed).

b. When RTS is used at the end of a subroutine, the registers in the stack are reloaded (or rather the contents of the stack are reloaded) back into the registers INCLUDING the Program Counter. Thus the program can carry on as if the jump to and back from the subroutine had never taken place. Even the Accumulators, Index Registers etc will still have their original contents preserved after the return, even if they were temporarily corrupted by the subroutine itself.

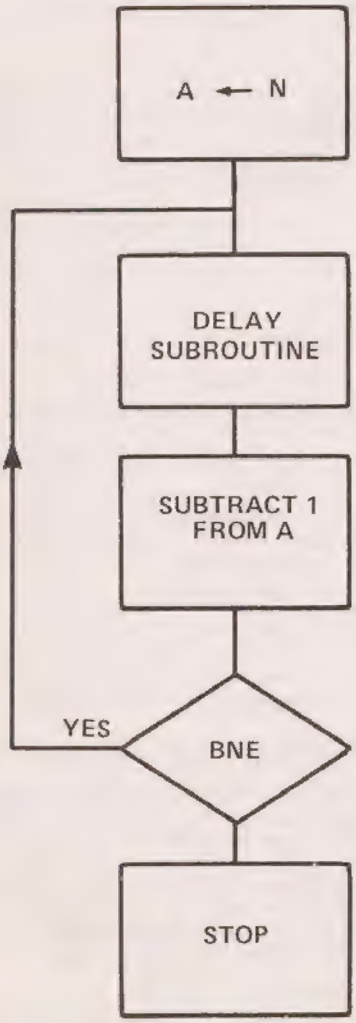
Returning to Program 12 again note that it uses a subroutine at Line–3. The code BD 0040 will cause a jump to "Program 11" (which of course is assumped to be in memory at address 0040). Note the last instruction in the subroutine is coded 39, which is a single byte instruction RTS. With regard to the logic of program 12, one or two useful little tricks are illustrated such as using an accumulator as a "loop–counter". This is a good opportunity to introduce a flowchart (which shows th e overall strategy of a program).

This program uses the maximum 0.85 second delay possible with the subroutine alone and "stretches" it out by using it "N" times, where N is the number loaded into ACC A. In example, N=10 and gives a delay of about 14 seconds, ie, the blank display time btween pressing the G button and the appearance of 000B 3F in red. If you have the time, change the value of N in Line 3 to 00 instead of 01 and note how long it takes to arrive at 000B 3F!

Program 11	PIA B OUTPUTS GO HIGH IF ANY PIA A INPUT GOES HIGH						
	0000	8E 00 FF		LDS		#00FF	Set SP
	3	CE 00 04		LDX		#0004	Initialise PIA A as
	6	FF 80 04		STX		8004	inputs
	9	CE FF 04		LDX		#FF04	Initialise PIA B as
	C	FF 80 06		STX		8006	outputs
	F	7F 80 04		CLR		8004	Clear PIA A and
	0012	7F 80 06		CLR		8006	PIA B
	5	B6 80 04	BACK	LDA	A	8004	Test if any input is
	8	27 FB		BEQ		BACK	HIGH
	A	73 80 06		COM		8006	Change PIA B output states
	D	3F		SWI			

This program uses that diabolically brilliant device known as the PIA (Peripheral Interface Adapter). It is brilliant in action but, because of the flexibility built into the thing, requires a considerable amount of mental torture before confidence is gained. The MOTOROLA PROGRAMMING MANUAL defines the action of the various registers which lurk within its silicon bowels but it will do no harm to repeat a few of the less obscure features:

a. The PIA consists of two almost identical halves, called the A side and the B side.
b. Each side has three registers, the DATA REGISTER, the DIRECTION REGISTER and the CONTROL REGISTER.



Flowchart for the delay subroutine on the left.

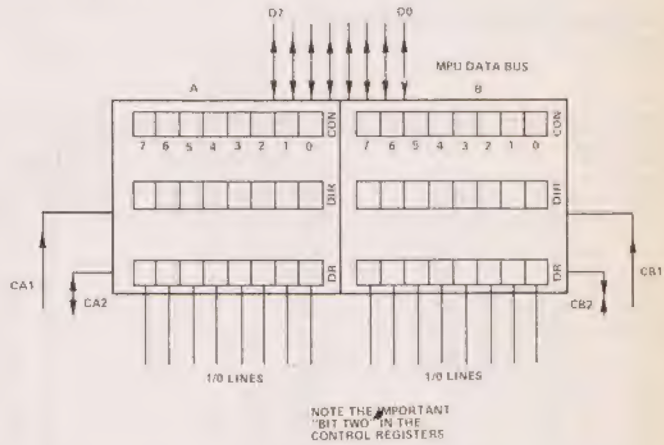
c. These registers can be used by knowing where they are situated in the memory mapping. In the D2 kit, they have been allocated the following addresses,

A SIDE		B SIDE	
DIRECTION REGISTER	8004	DIRECTION REGISTER	8006
DATA REGISTER		DATA REGISTER	
CONTROL REGISTER	8005	CONTROL REGISTER	8007

Note that the Direction and Data registers "share" the SAME ADDRESS

d. The address 8004 is the A side DIRECTION register if BIT TWO in the A side CONTROL register is a "0" but the DATA register if a "1"
e. The DIRECTION register defines which of the eight data wires in each half are inputs and which are outputs, the RULE being:
"0" = input "1" = output
Thus under RESET conditions, when all PIA registers contain ZEROs, the address 8004 will refer to the DIRECTION register of the A side and the address 8006 to the DIRECTION register of the B side.

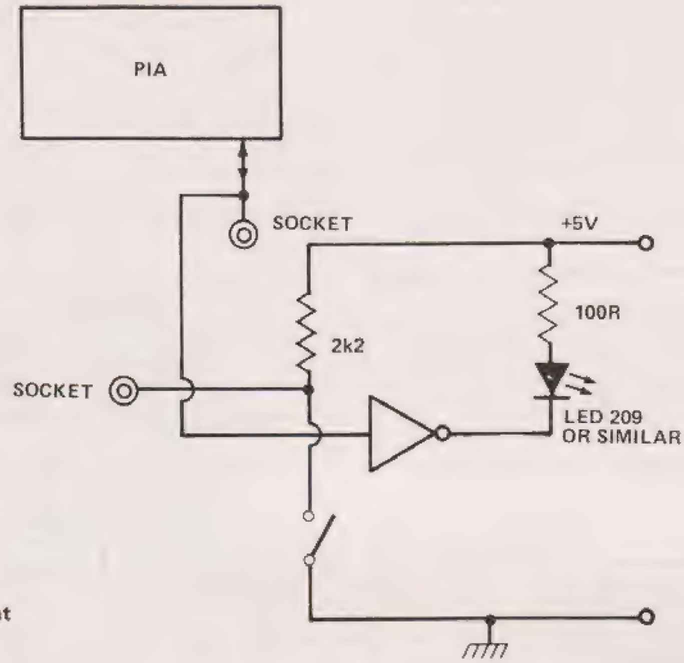
A small diagram may not be amiss here:



Until we start using the "handshake lines" CA1,CA2,CB1 and CB2, there is no need to know anything else about the CONTROL registers apart from BIT TWO. As soon as you have set the required directions of the I/0 lines, bit two should be set to "1", the remaining bits can be left all "0". Thus after setting direction, load the pattern 04 into the control register to ensure that in future, the DATA register is addressed by 8004 (A side) or 8006 (B side).

Returning now to the actual program; the A side I/0 lines are to be INPUTS and the B side I/0 lines are to be OUTPUTS so it follows that we must load the hex pattern 00 in the A side DIRECTION register and the pattern FF in the B side. Now the INDEX register X can be used to set the direction and the control register in one go because these occupy CONSECUTIVE ADDRESSES (refer back to program 7). Now examine Line 2 of Program 13 together with Line 3. Note that 00 will be placed in address 8004 (lower order byte of X) and 04

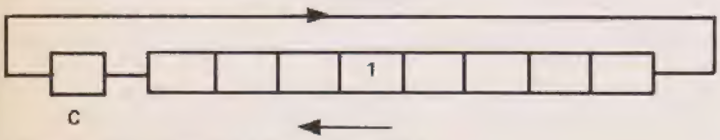
in 8005 (the higher order byte of X). Thus we have set the DIRECTION register as inputs and set bit two in the CONTROL register. This really means that we have no further use for the direction register and in future, the address 8004 is to refer exclusively to the DATA register.
Lines 4 and 5 initialise the B side as outputs (note the pattern is this time FF04 instead of 0004). Lines 6 and 7 simply ensure that both data registers start "empty".
Lines 8 and 9 perform the test (see if any input has gone high). This is done by loading the A side PIA into an ACCUMULATOR and branching back if it contains all zeros. In fact the computer will be rushing round and round lines 8 and 9 thousands of times per second, waiting patiently for someone to turn on a switch. When a switch, any one, is finally turned on, the computer (with a sigh of relief) will at last reach Line 10 which is Complement PIA B side; in other words, turn every lamp from OFF to ON.
It is assumed that the D2 kit has been equipped with a set of lamps and switches on the A and B sides of the PIA. A typical system which has proved simple and quite satisfactory is shown below.
All PIA I/O lines and handshake controls terminate in a socket, for experimental connections to external logic. This socket is permanently monitored by a LED lamp via an inverter (LS 7404). An input socket is provided close to all I/O lines which provides a TTL logic switched source. Note the output is HIGH with the switch open and LOW when it is closed. For a fully flexible system, twenty of the circuits are required (16 data lines and 4 handshake lines).
The LS (Lower Power Schottky) species of inverter doesn't steal much current from the PIA I/O lines thus allowing reasonable brilliance for the LED with still the odd milliamp to spare for driving external logic gates. Note that when the RESET button is pressed the PIA outputs "float" to the HIGH state. Thus the inverter outputs are LOW turning ALL THE LEDS ON. This was an unintentional bonus, useful for checking out the lamps. It is a useful exercise to run program 13 through under singleshot conditions (using the V and N buttons) in order to check which instruction turns the lamps off.



Circuit diagram for the PIA experiment program.

Program 12	ROTATE A "1" ROUND PIA A WITH DELAYS						
1	0000	8E 00 FF		LDS		#00FF	Set SP
2	3	CE FF 04		LDX		#FF04	Initialise PIA A
3	6	FF 80 04		STX		8004	
4	9	7F 80 04		CLR		8004	Clear PIA
5	C	0D		SEC			Set carry bit
6	D	CE 00 00	B	LDX		#0000	
7	0010	09	E	DEX			Delay
8	1	26 FD		BNE		E	
9	3	79 80 04		ROL		8004	Rotate
10	6	20 F5		BRA		B	

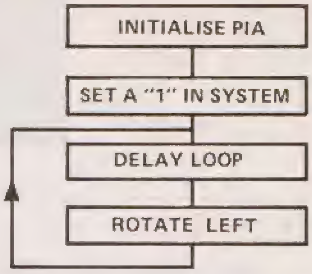
Provides an example of the instruction ROL (Rotate Left). Any pattern within a register (or a memory location) can be endlessly revolved by successive ROL instructions. The following diagram of the action of ROL is almost self-explanatory:



Flowchart for rotating a bit round the PIA.

Bits are shifted left one place by ROL and, via the "CARRY" bit, re-enter again at the right hand end. Note that there is room for a NINE—BIT pattern in the loop. Suppose a single binary "1" is required to circulate around the system, say the PIA. The simple way is to first clear the PIA and then use SEC (set carry) which is a single-byte instruction. This places the single "1" in the system which will now circulate one bit at a time for each execution of ROL.
Lines 2 and 3 initialise the A side of the PIA to behave as Outputs.
Lines 4 and 5 ensure the "1" is in the system.
Lines 6, 7 and 8 will probably be recognised from previous work in PROGRAM 11 where it was called a "Subroutine to cause a delay". To break the monotony and to provide a "theme and variations" it is not being used here as a subroutine because there is no RTS.

Instead, the three instructions are simply employed within the body of the program and after X = 0, the program exits to line 9.
Line 9 is the actual rotate instruction and is followed by an unconditional branch back to line 6. Thus the rotation of the "1" is continuous and will appear as a single lamp "moving" from right to left.
The speed of rotation can be increased by changing the operand in line 6. Try changing 0000 to 1010.
The following flow chart shows the idea behind the program.



Flowchart for the program.

Program 13	CLEAR CONTENTS OF ADDRESSES 40 TO 50 INCLUSIVE					
1	0000	8E 00 FF		LDS	#00FF	Set SP
2	3	CE 00 00		LDX	#0000	Clear X
3	6	6F 40	LOOP	CLR	40, X	Clear contents of (40 + X)
4	8	08		INX		
5	9	8C 00 11		CPX	#0011	There are 11 addresses
6	C	26 F8		BNE	LOOP	to be cleared.
7	E	3F		SWI		

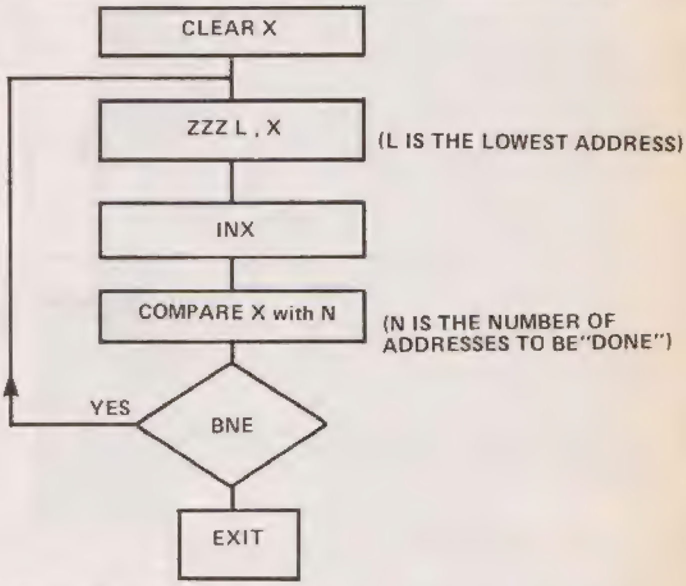
This introduces the concept of INDEXED ADDRESSING, an ingenious little trick for performing the same process on adjacent memory locations. Most of the instructions in the M6800 repertoire can be used with Indexed addressing mode so it is essential that an apprenticeship in programming includes this useful dodge in the syllabus.
The assembly format for indicating Indexed Addressing is as follows:

ZZZ BB, X where ZZZ is the normal OP Code, BB is the Operand and X implies the INDEX REGISTER.

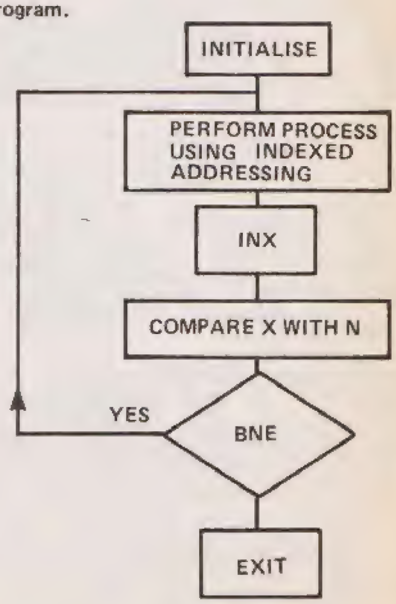
The actual address (known as the absolute address) is not BB but obtained by adding the contents of X to BB.
Example: Suppose the instruction is LDA A 05, X. If by chance, X contains 03, the absolute address will be 08. Thus the ACC A will be loaded with the contents of address 08. The value of indexed addressing can be stated as follows:

INDEXED ADDRESSING allows the same instruction to operate on consecutive addresses by incrementing the INDEX REGISTER each time round a loop.

Program 16 will now be examined line by line:
Line 2 simply clears the index register to zero.
Line 3 is the important one; CLR 40, X which will clear contents of address 40
(because X starts off with zero inside it)
Line 4 adds 1 to X, using the single byte instruction INX.
Line 5 compares the contents of X with the number 11 (because there are 11 addresses to be cleared altogether).
Line 6 is a branch back to line 3, causing the instruction CLR 40, X to be executed again but this time, because X contains 1, it will clear contents of address 41. The loop will revolve, clearing successive addresses until X has reached 10, thus clearing address 50. The final INX however will make X = 11 and the loop will exit at BNE to stop at SWI.
Because many programs perform the same operation on many consecutive addresses it is worth trying to arrive at a "general purpose" flow chart which can handle such a task.
To see if you have grasped this indexing lark, re-write the program so that addresses 42 to 56 inclusive are cleared———and test it afterwards!
Although the above example has dealt with a very simple process (just clearing addresses) the above general scheme will remain valid for more sophisticated tasks so it is well to study an even more generalised version of the flowchart.



General flowchart for the program.



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CT Systems Reviews

We have two for you next month, the new Acorn 6502 based kit, a super MK14 (some would say) and an even newer educational and development kit called the Nanocomputer.

Ancient and Modern

One of the things that we love to hear from you about are your applications for microcomputers. In this tale from the past a PET is being used to collate old parish records. Not a bit ghoulish either!

The PET Bus

Computer busses often seem to be misunderstood, the PET's no exception. In this article we delve in and give you the facts.

Dateline 5000 AD

Your chance to colonise the galaxy from the comforts of the armchair. Despatch your fleets to investigate 'target' stars, determine the mineral value etc, and (of course) do battle with the baddies. Star Trek eat your heart out.

BASIC Football Game

Mr. John N. Bell

This program was produced on a mini in "Standard" BASIC. It should be easily converted to run on any micro running the language. The game plays football and is fairly self-explanatory.

'Welcome to the old firm game at Ibrox, the rules are as follows; the park is 100 yards long and 50 yards wide, the goal is 10 yards wide and 9 feet high. There is a goalie in the goalmouth and you have to judge how hard to strike the ball in order to beat him. The strike range is between 0 and 125. You will be shown a diagram of the pitch.'

```
0001 PRINT "ARE YOU READY......(1)
     YES.....(2)NO"
0002 INPUT U
0010 IF U=1 THEN GOTO 0014
0011 IF U=2 THEN GOTO 0001
0012 PRINT
0014 PRINT "*********************
     *********"
0015 PRINT "* CELTS            *
               *"
0016 PRINT "*                  *
               *"
0018 PRINT "*                  *
               *"
0019 PRINT "****               *
            ****"
0020 PRINT "*   *              *
            *   *"
0021 PRINT "*__*______________*_______
     _______*___*"
0022 PRINT "*   *   CENTER    *   LINE
            *   *"
0023 PRINT "****               *
            ****"
0024 PRINT "*                  *
               *"
0025 PRINT "*                  *
               *"
0026 PRINT "*                  *
     GERS      *"
0027 PRINT "*********************
     *********"
0030 PRINT
0040 PRINT "WHAT SIDE ARE YOU....
     (1)RANGERS...OR (2)CELTIC"
0045 INPUT X
0046 LET R=0
0047 LET T=0
0048 IF X=2 THEN GOTO 0056
0050 IF X=1 THEN GOTO 0052
0052 PRINT "RANGERS KICK OFF"
0054 GOTO 0060
0056 PRINT "CELTIC KICK OFF"
0060 RANDOMIZE
0061 LET Y=INT(60*RND(0))
0070 LET Z=INT(24*RND(0))
0080 LET C=INT((Y^2+Z^2)^. 5)
0100 LET D=C+5
0110 LET E=C-5
0120 LET F=C+1
0130 LET G=C-1
0140 LET H=C-20
0150 LET I=C+20
0160 PRINT
0170 PRINT "THE BALL IS.....";Y"..
     YARDS FROM THE GOAL"
0171 PRINT "AND IS....."Z"..YARDS
     FROM THE CENTER LINE"
0180 PRINT "HOW HARD DO YOU WISH
     TO STRIKE THE BALL?"
0181 INPUT S
0182 IF S<=20 THEN GOTO 0391
0183 IF S>=100 THEN GOTO 0391
0184 LET A=S-40
0185 IF A>H THEN GOTO 0187
0186 GOTO 0196
0187 IF A<E THEN GOTO 0400
0188 IF A>D THEN GOTO 0190
0189 GOTO 0196
0190 IF A<I THEN GOTO 0400
0196 IF A<H THEN GOTO 0190
0197 IF A>I THEN GOTO 0320
0201 IF A=C-2 THEN GOTO 0380
0202 IF A=C-3 THEN GOTO 0380
0203 IF A=C-4 THEN GOTO 0380
0204 IF A=C+2 THEN GOTO 0380
0205 IF A=C+3 THEN GOTO 0380
0206 IF A=C+4 THEN GOTO 0380
0210 IF A=D THEN GOTO 0420
0220 IF A=E THEN GOTO 0420
0250 IF A=F THEN GOTO 0340
0260 IF A=G THEN GOTO 0340
0270 IF A=C THEN GOTO 0360
0280 IF A<H THEN GOTO 0320
0290 IF A>I THEN GOTO 0320
0300 IF A<E THEN GOTO 0400
0310 IF A>D THEN GOTO 0400
0317 PRINT
0320 PRINT "DEFENDER TACKLES
     AND WINS BALL"
0325 PRINT
0330 GOTO 0590
0340 PRINT "GOALKEEPER SAVES SHOT"
```

```
0345 PRINT
0350 GOTO 0530
0360 PRINT "SHOT HITS CROSSBAR
     AND GOES OVER"
0365 PRINT
0370 GOTO 0530
0380 PRINT "WHAT A FANTASTIC
     GOAL!!!!!!!!!!!"
0385 PRINT
0390 GOTO 0440
0391 PRINT "YOU HAVE JUST SCORED
     AN OWN GOAL!!!!!!!!!!"
0392 PRINT
0395 GOTO 0442
0400 PRINT "SHOT WENT WIDE......
     GOAL KICK"
0405 PRINT
0410 GOTO 0530
0420 PRINT "WOW!!!!!...SHOT HIT
     POST AND WENT PAST"
0425 PRINT
0430 GOTO 0530
0440 IF X=1 THEN GOTO 0450
0441 IF X=2 THEN GOTO 0470
0442 IF X=1 THEN GOTO 0470
0443 IF X=2 THEN GOTO 0450
0450 LET R=R+1
0460 GOTO 0490
0470 LET T=T+1
0480 GOTO 0510
0490 PRINT "CELTIC KICK OFF"
0491 LET X=2
0492 PRINT
0494 LET X=2
0495 PRINT "THE SCORE IS RANGERS..
     ";R"..CELTIC.. ";T
0496 PRINT
0500 GOTO 0680
0510 PRINT "RANGERS KICK OFF"
0511 PRINT
0515 LET X=1
0520 GOTO 0495
0530 IF X=1 THEN GOTO 0550
0540 IF X=2 THEN GOTO 0570
0550 PRINT "CELTIC HAVE BALL
     AFTER KICK OUT"
0551 PRINT
0555 LET X=2
0560 GOTO 0060
0570 PRINT "RANGERS HAVE BALL
     AFTER KICK OUT"
0571 PRINT
0575 LET X=1
0580 GOTO 0060
0590 IF X=1 THEN GOTO 0610
0600 IF X=2 THEN GOTO 0640
0605 PRINT
0610 PRINT "CELTIC HAVE BALL"
0620 LET X=2
0630 GOTO 0060
0640 PRINT "RANGERS HAVE BALL"
0645 PRINT
0650 LET X=1
0660 GOTO 0060
0680 LET Y=T+R
0690 IF Y=6 THEN GOTO 0700
0691 IF Y=8 THEN GOTO 0710
0692 GOTO 0060
0700 IF T=R THEN GOTO 0750
0705 PRINT
0710 PRINT "THE FULL TIME
     WHISTLE HAS GONE DO
     YOU WISH TO PLAY AGAIN?"
0720 PRINT "...(1)YES....(2)NO..."
0725 INPUT V
0730 IF V=1 THEN GOTO 0040
0735 IF V=2 THEN GOTO 0800
0750 PRINT
0751 PRINT "THE FULL
     TIME WHISTLE HAS GONE,
     DO YOU WISH TO PLAY ANY"
0752 PRINT "EXTRA TIME?"
0755 PRINT "...(1)YES...(2)NO..."
0760 INPUT W
0770 IF W=1 THEN GOTO 0060
0780 IF W=2 THEN GOTO 0870
0800 IF T>R THEN GOTO 0830
0810 IF R>T THEN GOTO 0860
0830 PRINT
0840 PRINT "CELTIC--CELTIC--CELTIC
     ....ECHOES THROUGH THE GROUND"
0841 PRINT "AS THE CELTIC
     FANS CELEBRATE YET
     ANOTHER FAMOUS OLD"
0842 PRINT "FIRM VICTORY
     OVER RANGERS"
0850 GOTO 0870
0860 PRINT ""
0861 PRINT "WE ARE THE PEOPLE...
     WE ARE THE PEOPLE...
     WE ARE THE PEOPLE"
0862 PRINT "CHANT THE  RANGERS
     FANS AS THE FAMOUS
     GLASGOW RANGERS"
0863 PRINT "THUMP CELTIC ONCE
     AGAIN AT IBROX STADIUM"
0870 END
```

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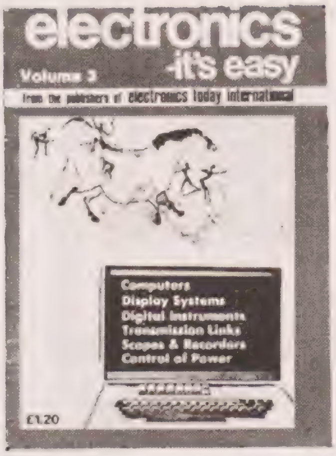

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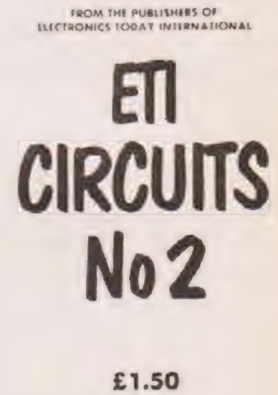

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APPRECIATING MPU's

An explanation of the why's and wherefore's of the microprocessor revolution

Periodically, the media goes berserk over some device which is supposed to "revolutionise technology", their latest toy being the poor microprocessor. In fact, the microprocessor is in no way revolutionary; it was the inevitable consequence of circuit integration which began in the mid sixties when someone managed to persuade more than one transistor to rest on a silicon chip. (The media can't even get this right ——— they call it the silicone chip which indicates some relation exists between microprocessors and furniture polish).

Evolution

The cost of developing an LSI chip is high, very high and can only become a profitable exercise if the sales are enormous. But———the more complex the IC the more dedicated it becomes and the global demand falls. In 1971 a small firm (no longer small) called INTEL launched a general purpose computing chip which they called a "microprocessor". Because of the unrestricted applications of the device, the deadlock was broken. Without in any way wishing to deny INTEL the glory they deserve, there is little doubt that in 1971, if INTEL had not produced the microprocessor somebody else would have done. There was a need for it so it was invented. Prior to the middle of the 18th Century there was no desperate need for the calculus but when the need arose, it was invented simultaneously by Leibnitz and Newton. Thus the microprocessor was evolutionary rather than revolutionary.

Impact

The impact of the microprocessor on technology can be summed up in one sentence. It has enabled computing power to be used in situations, which prior to its introduction, would have been dismissed as outrageously expensive. Computing power enables sophistication, intelligence and versatility to be built into any system. Thus multimeters, signal generators, wrist-watches and door-chimes are beginning to boast of a microprocessor "brain".

Another spin-off is the growing popularity of what is called "Distributed Processing". Thus instead of a large central processor having elevated status, completely controlling every trivial activity of its subordinate peripherals, it is now economic and sensible to delegate power to the various subsystems. Distributed Processing is not a new idea; it is just that microprocessors have allowed it to flourish.

Home Computing

The year 1978 will be remembered in the UK as the dawn of the home computer. Perhaps the most outstanding event of the year was the launching of the PET 2001 by Commodore Business Machines (CBM). Inside this neat cabinet (fit enough in appearance to sit on a lounge table) was a microprocessor, some semiconductor memory chips, power supply, a keyboard with full ASCII plus graphics, a tape cassette backing store and a VDU display. It could be programmed in Assembly language or BASIC with an ambitious operating system almost self-explanatory in use. The launching price was about £700 but early in '79 was reduced to £499. For those who have grown up through the computer age, a price like this must have been unbelievable.

The ubiquitous PET home computer.

Only three or four years prior to the PET, equivalent computing power would have cost something in the order of £5000. Bearing in mind inflation over that period the relative cost has dropped by a factor of almost twenty to one. Anyone who doubts that the home computing craze is here to stay would be advised to examine the bookstalls. The competition in this comparatively new market is fierce and it is doubtful if the PET will retain its present dominance.

Application

The obstacle in the road of microprocessor development at the moment is not programming. It is invention of APPLICATIONS. We are not yet used to the idea of cheap computing devices freely available over the shop counter. Computers have been around for many years in the role of the mathematical or clerical labourer but their insides have been taken for granted. An engineer, technician or manager considered a computer as a general purpose tool which crunched up input data and presented "answers". The computer was the keyboard! Conversations were carried out in almost plain English with the help of operating systems designed to enabled almost anyone to benefit from the computer without necessarily knowing anything about computers.

It is the cheapness of the microprocessor which will force it to intrude into the engineering environment, not in the traditional computing role of a "question and answer data crusher" but as the controlling power in some comparatively trivial black box.

What Is A Microprocessor?

A traditional "computer" was considered to be a black box containing the following subsystems:

a. Central processor (consisting of a control unit and

arithmetic and logic unit)

b. Internal memory to store instructions and data and constructed from tiny magnetic cores which were able to retain their information even if the power supply was switched off——a so–called NON VOLATILE memory.

c. An input/output buffer to communicate with peripheral devices such as teletypes, tape or disk backing-stores.

The internal core memory of the computer was very expensive and because its manufacture was labour-intensive, the device showed signs in the early seventies of succumbing to the new technique of "semiconductor" memories. They were much faster, less bulky, consumed less power and were more reliable.

As mentioned, INTEL decided to launch an IC which contained all the logic required for the function of Central Processor. Thus a provisional definition of a microprocessor is simply the "central processor part of a computer". To produce a fully operational "computer", it is necessary to connect a memory chip (or chips) and another chip designed to act as an input/output interface. (Such is the rate of advance in this area that before long, most manufacturers will integrate all three chips into one).

Microprocessor systems emulate the Meccano principle. Buy the microprocessor chip, as much memory as desired and an I/O chip and wire up. In order to allow such flexibility, the microprocessor chip is equipped with three bus systems called the ADDRESS BUS, the DATA BUS and the CONTROL BUS. They have the following functions:

a. ADDRESS BUS is used by the microprocessor to select a particular memory location according to the address code it puts out on the bus.

b. DATA BUS collects data from memory or stores data in memory.

c. CONTROL BUS is a collection of lines carrying pulses to synchronise the system and to tell the memory when to output data and when to allow fresh data in.

Figure 1 shows the plan:

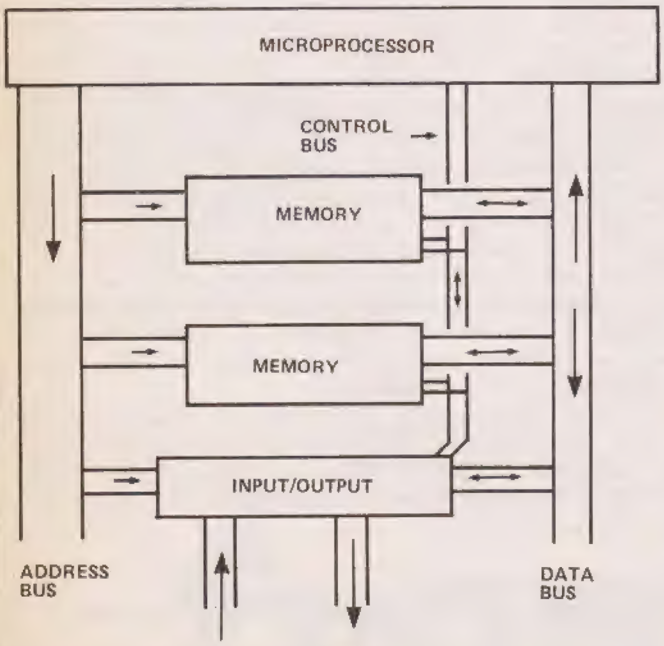


Figure 1. Internal structure of an MPU.

The Address Bus

The number of wires in the address bus determines the maximum number of memory locations which can be uniquely addressed. This is because every memory location must have a unique address code.

Most microprocessors have 16 wires in the address bus, so it would be possible to build up the memory to a maximum of 2^{16} which is 65,536. This is a convenient time to introduce the symbol "K" used as a shorthand unit in binary systems:

$$1K = 2^{10} \text{ (which is 1,024 decimal)}$$

Thus instead of relating 2^{16} to an awkward decimal number, it becomes a round 64K.

It would be most unusual for a system to require 64K of memory.

Note from Figure 1 that the address bus is uni-directional; the information can only come from the micro-processor. The voltage levels on the bus are normally standard TTL, ie a HIGH is any voltage between 2V4 and 5V and a LOW is any voltage between 0 and 0V4. The available current drive from the bus wires is unfortunately seldom sufficient to drive all the required memory chips unless extra buffer drivers are used.

The Data Bus

The number of wires in the data bus defines the word-length of the system. A simple definition of word-length is the number of bits transferred or processed by a computer instruction. Alternatively, word-length is the "width" in bits of a memory location and is probably the most important parameter in a computing system. Most microprocessors have a word-length of EIGHT bits which is very short when compared with traditional minicomputers. Nevertheless, for the role of controlling a system, 8 bits is normally adequate.

It has become accepted that a block of eight bits is termed a BYTE; most modern computing systems are "byte-orientated" because the standard keyboard code is the ASCII (American Standard Code for Information Inter-change). Pressing one key on an ASCII keyboard outputs a seven bit group of bits which is normally joined by an error checking bit (known as the parity-bit), bringing the total up to 8 bits.

One of the inevitable results of standardisation is the growth of variations! Thus there are variations on the ASCII such as the "restricted" form of six bits (allowing only 64 different characters instead of 128).

A glance at Figure 1 confirms that the data bus is bi-directional to allow the microprocessor to place new data in memory (called writing) and to allow adata in memory to be routed into the microprocessor (called reading).

One difficulty of the 'Meccano' system is ensuring that only one byte of data is on the data bus at one time. Figure 1 shows that the data wires of all the boxes are conn-ected to the one data bus. There are two solutions:

WIRED OR

The memory output buffers to the data bus are the "open-collector" type which demands that pull-up resistors are required on each bus line to the +5 V power line (assuming of course the buffers are TTL.) This is generally regarded as a sloppy solution.

TRI–STATE–CONTROL

A two state logic output is either in the HIGH state

or the LOW state. A tristate logic system has an extra, non functional state which presents a high (ideally infinite) impedance to any line to which it is connected. Thus a memory box with tristate output buffers can be made to appear non-existant to the data bus. However many boxes are connected across the data bus, providing only one is functional at the same time, there is no chaos.

The Control Bus

This is a hotchpotch of wires, each having a dedicated function. Some of them are outputs to the memories, some are signals from the memories, some may be "messages" from the outside world (peripherals). Their number and function will depend on the particular microprocessor type, which in turn will depend on the degree of sophistication offered. The following are more or less typical of most microprocessors:

RESET

A signal from this input (usually from an external push-switch starts an initialisation routine which sets the internal registers to zero and outputs a special address code.

READ/WRITE

This is an output from the microprocessor to inform the memory chips when they are to READ onto the data bus or WRITE from it. It is usually a single wire and could be marked R/W, which is an abbreviated symbolism to indicate that when the wire is in the HIGH state it is commanding the memory to READ and when LOW write.

VALID MEMORY ADDRESS (VMA)

Although some species of microprocessor differ in the way synchronisation is achieved most of them use one clock pulse to send out an address on the bus, and the next one to read the contents onto the data bus. Some time interval must elapse before the address bus has stabilised (even if it is only a few nanoseconds) so the microprocessor sends out a VMA signal which is arranged to be comfortably delayed on the clock pulse. By ANDing this with the clock and the R/W line, the data is made healthy.

INTERRUPT REQUEST

"Interrupt" is a technique allowing a peripheral device to barge in on the computer and divert its attention to another program previously written for the peripheral, ie, it is a peripheral initiated subroutine. After the peripheral servicing (which may be something quite ordinary like inputting one character from a teletype) the computer returns automatically to the point in the program at which it was interrupted. To initiate an interrupt, a wire is provided called IRQ which when activated, will REQUEST permission to interrupt. This is granted, subject to the state of a special control bit called the "interrupt" (which is programmable).

NON–MASKABLE INTERRUPT

This line (when present) has higher priority than IRQ and is not subservient to the state of the interrupt mask bit.

Semiconductor Memories

There is an abundance of memory chips available differing in semiconductor type, word-length, access time and of course capacity. There is also an abundance of related jargon which demands explanation:

CAPACITY

Superficially, the capacity of a memory is the amount of information it can store. Capacity can be measured in terms of how many BITS it can store or how many WORDS it can store. Most memories, intended for microprocessor use, are arranged in blocks of "pigeon-holes" each storing one byte (8 bits).

Thus a memory chip described as "1K X 8" would hold 1024 bytes of information. Each of the 1024 pigeon holes or LOCATIONS would have a unique ADDRESS CODE associated with it.

Since 1971, technology has developed a lust for packing more and more locations into less and less space. The latest craze is the media's obsession with the "64K" memory, although they appear disinterested in whether this means bits or bytes!

SEMICONDUCTOR TYPE

There are two primary divisions:

Bipolar, employing normal bipolar junction transistors. These are very fast, relatively expensive and seldom necessary in the majority of microprocessor applications.

MOS, cheaper than bipolar, capable of higher packing densities but not as fast. Until recently, the majority of MOS memories employed p-channel enhancement mode which required two supply voltages, one of which was (rather awkwardly) negative to ground. In spite of early difficulties, n-channel MOS memories are now becoming commonplace and because of the single +5 V power supply, are very popular.

STATIC OR DYNAMIC

The primary storage element in a "static" memory is the bistable flip-flop which can rest in either of two states. In contrast, the "dynamic" memory is virtually a capacitor storage register which must be kept refreshed. The 1s and 0s are stored in the inter-electrode capacitance of MOS transistors. To ensure stored data is preserved, a "refresh" cycle is required every few milliseconds. Thus; STATIC memories store data, even at rest; DYNAMIC memories require periodic refresh cycles. This is an annoyance to grin and bear if large capacity memories are required at minimum cost.

RAMS and ROMS

Traditional computing engineers were accustomed to core memories which were supposed to be non-volatile. After switching off at night, they expected their data to be available again in the morning (an optimism not always justified).

The introduction of semiconductor memories, capable of being read from and written in to in the same way as core memories, forced engineers to abandon their loyalties to non-volatility (always a kind of sacred cow). For some unaccountable reason, semiconductor memories with read/write functions are called "RAMS" (which originally meant Random Access Memories to distinguish them from

sequential access backing stores such as magnetic tape drives).

It is not difficult to appreciate that the ability to read and write is a valuable asset but the habit of losing data everytime the power is interrupted can be downright unpleasant. Fortunately, there are ROMS.

ROM stands for "Read Only Memory", implying that in return for the non-volatility we have to forego the ability to write new information into it. There is of course an obvious question: How did the data get into the ROM in the first place? There are two types of ROM:

MASK PROGRAMMABLE ROMS.
The user tells the manufacturer the bit-pattern required and a mask is prepared which produces the ROM. This is expensive as a "one-off" but tolerable in mass-production projects.

USER PROGRAMMABLE ROMS.
The ROM is supplied "naked" and the user can "burn" in the required bit pattern———but there is no second chance if even one bit is entered in error since it can't be changed.

PROMS

This stands for Programmable Read Only Memory, a sickly example of modern gobbledegook resulting from the craze to force an acronym into existance. Superficially the PROM would appear to be the same as a RAM because if it can be read from and new data can be programmed in then technically it is a RAM! Nevertheless, there is a difference:

A PROM can be read normally but its data can only be changed by erasing the old data (by a special process) and re-programming with special voltage pulses. If a mistake is made, the PROM can be erased again and the process recommenced.

The most popular PROM on the market is the "ultra-violet erasable" which has a small transparent quartz window on the top, directly above the active chip area. To erase the data, the chip is placed in a box fitted with a powerful ultra violet lamp.

Connecting Memories

This is best explained with the aid of a diagram (Figure 2).

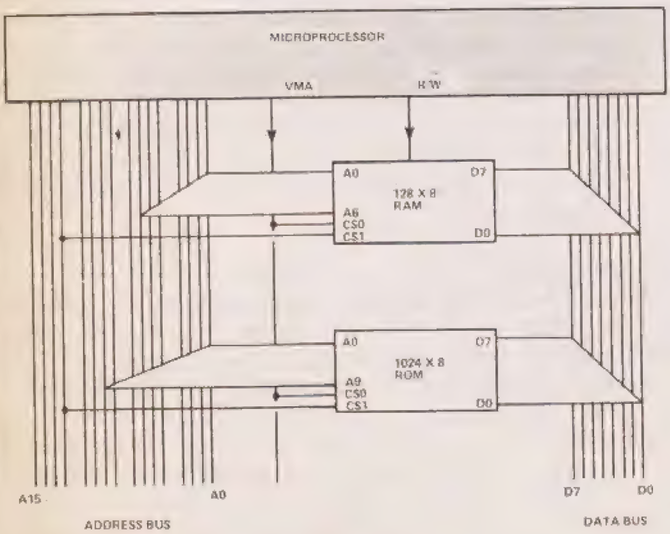


Figure 2. Hanging memories onto a bus.

There are two categories of address wires on a memory chip:

a. INTERNAL ADDRESS wires to select a particular location, the number of them depending on the memory capacity. Thus the RAM shown in Figure 3 has seven, allowing 128 different address codes. They are labelled A_0 to A_6 and connected to the corresponding lower-order address lines on the microprocessor address bus. The ROM requires ten internal address wires, labelled A_0 to A_9 in order to select any one of 1024 address codes. These are also connected to the corresponding lower-order lines on the address bus.

b. CHIP SELECT wires to select which chip is to be "enabled". The term "enabled" means to make functional or make "live". A "disabled" box is dead. In practice the chip select wires control the tristate output buffers to the data bus;
The number of chip select wires on any make of memory varies, some have as many as six. However many there are, they must ALL be enabled to make the box live. They are usually labelled, CS0, CS1, CS2 etc. although some are crowned by the negator bar indicating they must be held LOW to enable. The chip select wires are connected to the higher order address lines in any arbitrary arrangement providing it is impossible for any address to enable two or more boxes simultaneously; addresses should be mutually exclusive.

Notice that only the RAM requires a R/W driver: the ROM can only read!

Input/Output Ports

Microprocessor systems connect with the outside world via buffer stages known as "ports". The design of these ports would appear to be a trivial exercise, unworthy of a special paragraph; indeed, some manufacturers share this view and merely provide a few pins on the microprocessor chip. Others have different ideas, considering the I/O ports merit status almost equal to that of the microprocessor itself and produce special ICs as part of the package deal.

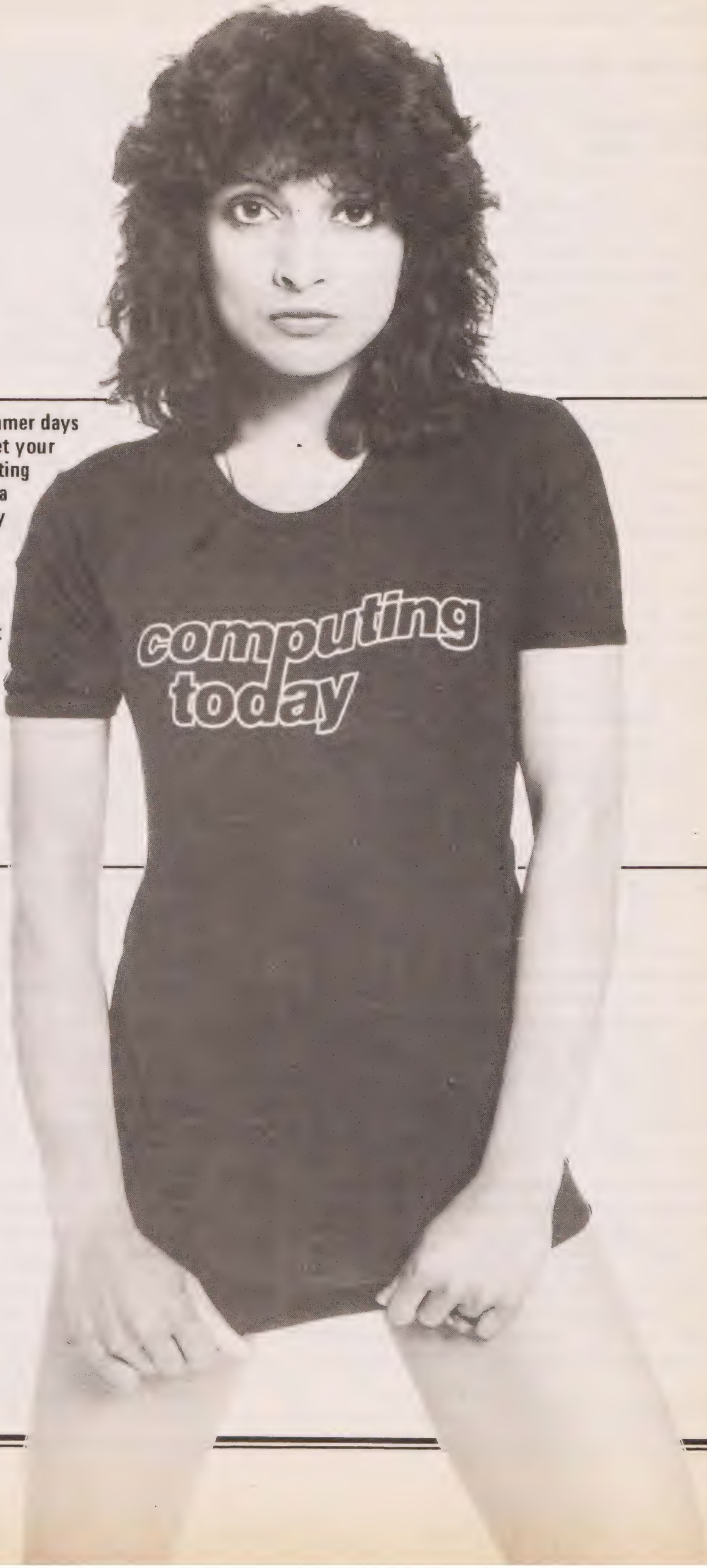
a. SERIAL, meaning the input data is received bit by bit, each arriving one after the other. Most teletypes deliver data words in serial form and receive them in the same manner.

b. PARALLEL, meaning data words can be delivered or received in parallel. These have a higher selling power than serial because, in principle, they can combine both functions. They may be called Peripheral Interface Adapters (PIA), although manufacturers choice of names are often quite exotic.

It follows that any I/O port IC must contain some registers in order that:

c. input or output data can be buffered (often called data registers).

d. to set the desired direction of data, ie, whether a particular line is to behave as an input or an output. These matters are often decided by the pattern of bits programmed into the direction registers. These of course would only be necessary if the peripheral lines were undedicated.



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e. control registers to program a particular behaviour response (if there are many to choose from).

Programming I/O Ports

There are two methods:

a. By the use of special I/O instructions.

b. By treating the port as a memory location (or group of locations). For example, suppose a particular PIA has four internal registers and the specification demands they be allotted consecutive address codes, it follows that the system designer can wire up a PIA anywhere he chooses with the knowledge that only four address codes are "wasted". This method is known as the "Memory Mapped" I/O port and is more flexible because there is no limit (apart from the upper limit of 64,536 address codes) on the number of PIAs which can be connected.

A Typical PIA

Figure 3 shows the interface presented to peripherals by the Motorola PIA , which is a good example of a memory mapped I/O port.

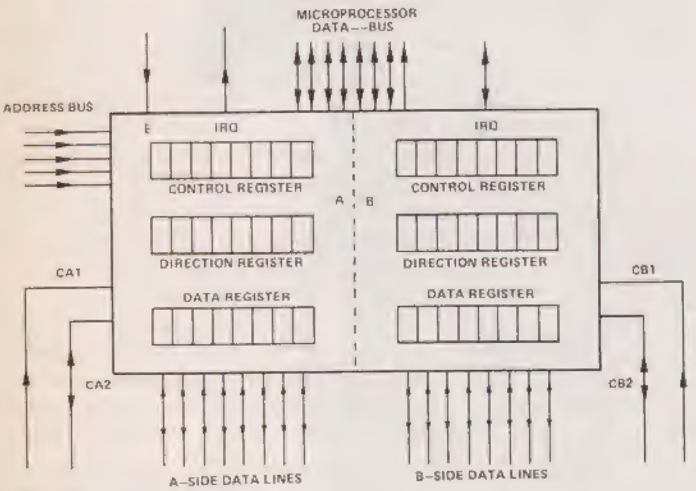


Figure 3 The Motorola PIA.

For precise details, consult Motorola data sheet on the IC but the basic facts are as follows. There are two virtually identical halves (side A and side B). Each of the 8 data lines can be programmed independantly of each other as inputs or outputs according to the pattern of 1s and 0s in the direction register. The programmer can place a "1" in this to define the corresponding data wire as an output and a "0" to define an input.

The primary object of the control register is to define the behaviour of the special "handshake" lines CA1 and CA2 on the A side (CB1 and CB2 on the B side). CA1 is dedicated as an Input which can be used to set a "flag bit" in the control register and (if the programmer desires)cause an interrupt request. CA2 can also behave in the same manner but can also be programmed to behave as an Output. The handshake lines are a valuable addition to the versatility of the PIA, particularly when handling peripheral machinery.

Field Of Choice

Assume that you are thinking of using a microprocessor to control "something" and a preliminary outline system is simmering somewhere in the back of the mind. How do you decide on which microprocessor? Is it to be an INTEL 8080, a MOTOROLA 6800, a ZILOG Z80, a TEXAS 9900 or a ROCKWELL, a FERRANTI etc.

The trouble is there is *too much* information about them, *too many* glossy sales brochures, *too many* embarrassingly polite salesmen eager to "explain" the relative superiority of their particular product. Adding to the confusion is the falling prices and the increase in sophistication of the new species (or "Mark 2" models of existing species). In fact the situation is a classical example of Sods Law.

We can proceed to dissect out the individual features which appear in the brochures. Only facts are given and no attempt will be made to compare actual processors.

Word Length

Most microprocessors have an 8 bit word length, one or two have 12, and an ever increasing number of the new varieties have 16 bits. Ignoring the 12 bit (which frankly is a bit of an oddity in the modern climate) the question is which is the best?

For a given clock frequency, a 16 bit microprocessor can process data at twice the speed of an 8 bit. Arithmetical quantities expressed as a 16 bit positive integer are accurate to 1 part in 65,536 whereas 8 bits are accurate to 1 part in 256.

If a microprocessor is considered as a number-crunching "calculator", the above arguments clearly brand the 8 bit as a poor relation. If for example the intention is to make a microprocessor the brain of a fully fledged desk-top computer, capable of programming in BASIC or FORTRAN and able to project fascinating pictures on a CRT, the 16 bit has the edge.

But there is a credit side to the 8 bit microprocessor. It is cheaper, there are more of them about, they have at least 8 pins less on the chip (unless the 16 bit job employs a rather irritating trick called "multiplexing") and when employed on system control (rather than number crunching) tend to be less wasteful on memory. It is possible to use "double precision" arithmetic in which two memory locations are used to store double length words. This is not difficult either but, as mentioned before, tedious. Although open to the charge of over-simplification, it appears that the subject of word length can be resolved as follows:

> If most of the data handled is of 8 bit precision there is little overall benefit in choosing a 16 bit microprocessor.

Clock Frequency

All microprocessors require some form of clock to provide the master timing pulses. Some of the later arrivals have a built in clock circuit so only the external crystal need be supplied extra. In general, the higher the clock frequency the greater the "throughput" (an ugly but quite descriptive jargon word which means how fast data is processed). The user has a certain amount of freedom in choice of clock frequency subject to an upper frequency limit and, strangely, a lower frequency limit. Most microprocessors are designed with dynamic internal registers which must set a minimum clock frequency. Typical upper frequency limits vary from 500Hz (considered slow), 2MHz (considered reasonable) to above 5MHz which is fast!

However, it must not be thought that a high clock frequency automatically implies high throughput. Other

things being equal then of course a high clock frequency must mean a speedier work force. But other things are seldom equal. For example, the number of clock cycles required to perform the "average" instruction is as important as clock frequency. Thus a microprocessor working at 2MHz clock frequency may take four clock cycles to execute an "Average" instruction, whereas a competing species may operate on 1MHz clock but only take two clock cycles to execute this instruction. Thus from this viewpoint they are both as fast.

Number Of Accumulators

A computer requires somewhere to breathe, to carry out the various arithmetic and logical processes which the programmer directs. It is not easy to perform these operations on data residing in memory so certain registers are provided equipped with complex electronic circuits. The data can then be placed into these registers, processed and perhaps returned back to memory. These general purpose registers are called accumulators.

Some microprocessors have only one accumulator, some two and some have eight or more. There is no doubt that multiple accumulators make for easier programming and can increase throughput. Thus if there is only one accumulator, there is a continual "to and froing" between memory and accumulator, ie, tedious repetition of load and store instructions because of the lack of breathing space.

It is worth mentioning that the TEXAS 9900 is unique in having no accumulators at all! Instead, the programmer can pick a block of memory locations and virtually designate them as "accumulators" or "working space".

The Instruction Set

The pages of frightening hieroglyphics called the Instruction Set can strike terror in the hearts of some people (including the writer's). It is a list of all the machine instructions which the particular brand of microprocessor is capable of carrying out. It is an indispensable document to the machine or assembly language programmer, couched in precise legal terms and rich in symbolism. Every instruction is allotted a unique "machine code" (which the computer "understands" even if the human doesn't) and a corresponding group of letters having mnemonic value (which the computer doesn't understand but the human does). It is not profitable at this point to dwell too much on the gory details of the instruction set except insofar as they influence the choice of a microprocessor.

In general, there are two parts to a machine instruction:

a. The Operation Code (OP code) which tells the machine WHAT to do.

b. The Operand which tells the machine WHERE to find the data.

Thus the format of (most) instructions is as follows:

OP code	Operand

For example, using letter groups for the OP code (instead of machine numerals) an instruction might appear as:

ADD	34

ADD of course implies "add to the accumulator" but the "34" introduces a complication. Does it for example mean literally add the number 34 to the accumulator or does it mean add the contents of address 34 to the accumulator? It all depends on the machine code. Thus there will be several different types of ADD instruction depending on the significance to be attached to the operand. These variations on the ADD (or indeed any other instruction) are called addressing modes.

It is probably true to say that the number and novelty of the possible addressing modes available on each instructions is of greater value than the total number of instructions. Thus a processor with say, 200 different instructions with four addressing modes may very well be inferior to one with only 70 instructions but with seven or eight addressing modes.

It is convenient to first discuss the addressing modes which are common to almost all microprocessors which are:

LITERAL or IMMEDIATE———the operand is the data.

DIRECT———the operand is the address in memory of the data.

IMPLIED or INHERENT———no operand is required; the code itself is sufficient (example: clear Accumulator).

The more sophisticated addressing modes (and very powerful in programming) are not all found in every microprocessor:

INDEXED———the operand and the contents of an INDEX REGISTER are added together, the result being the absolute address of the required data. Useful for making the same instruction operate on different memory locations by changing the contents of the INDEX REGISTER.

INDIRECT———the operand is the address of a location in which the required address of the data is stored. (this should be read a few times before it makes sense).
Example: Suppose the operand is 34. Suppose also that in an address 34 is the number 56. Then,
34 is the INDIRECT ADDRESS
56 is the address of the required data.
Indirect addressing is used for the same purpose as Indexed addressing, ie, the indirect address can be changed to alter the effect of the instruction. However, indirect addressing is in many ways superior to indexed addressing because any memory location can be used as an indirect address instead of the limit imposed by having a single (or perhaps a few) index registers.

PRE-INDEXED INDIRECT———the operand and the contents of an index register are first added, the result is the location where the indirect address is stored. A good programmer can work "miracles" with this facility. Unfortunately, if he expires in the middle of a program it could be a nightmare for someone else to debug and complete.

POST-INDEXED INDIRECT———similar to pre-indexed but the contents of the index register is added to the indirect address to produce the absolute address.

RELATIVE———these are only used in BRANCH or JUMP instructions; the operand is a number indicating how many instruction address backward (or forward) the computer must jump to obtain its next instruction. The term "relative" means with respect to the current instruction address.

Hardware Within The Microprocessor

Instead of throwing a dead microprocessor chip away it will

be found a rewarding exercise to prise away the case (somehow?) to expose the active chip area. To the naked eye, only a blur of ridges and valleys appear but on the microscope stage, with say, a times four objective and times ten eyepiece, the full beauty is exposed. Even a low priced chip will probably contain twenty to forty thousand active semiconductor devices arranged in a geometric order which only a computer could design.
Having marvelled for a few minutes, forget it. Any attempt to unravel the detailed architecture will lead to despondency. For practical purposes, it is sufficient to be aware of the major registers available to the programmer and perhaps an overall crude idea of the operating sequence. The major registers common to most microprocessors are:

a. PROGRAM COUNTER is the major domo because the contents is the address of the next instruction to be executed. It is automatically incremented after each execution thus defining the rhythm of a "Von Neuman" machine, ie, instructions executed in numerical address sequence. The exception to the rhythm is when a Branch is executed and the Program Counter has an abrupt change of contents.

b. ADDRESS COUNTER contents determine the location of the data (operand). In fact the way in which a computer "knows" what is data and what is an instruction is simple:
If the address bus was loaded from the Program Counter it assumes it is an instruction.
If the address bus was loaded from the Address Counter, it assumes it is data.

INSTRUCTION REGISTER holds the OP code whilst it is being decoded and implemented. An instruction, although a single item of action as far as the programmer is concerned, requires many individual actions carefully worked out during the embyonic stage of design. Each different instruction must have its own set of steps, forming a "Microprocessor". The microprograms are stored in a ROM inside the microprocessor chip (not to be confused with the external ROM which hold the program). The contents of the Instruction Register hold the starting address of the microprogram; the OP code becomes an address!

DATA REGISTER is the buffer between the microprocessor and the external data bus and is bi-directional.

ADDRESS REGISTER is the buffer between the microprocessor and the external address bus.

ACCUMULATOR/S have been previously described as general purpose registers available to the programmer.

INDEX REGISTERS, used in the indexed addressing mode, often double-length.

STACK POINTER is in some ways similar to the Program Counter except it points to the address of a data item instead of an instruction. Special instructions called PUSH and PULL (or Poke and Pop) allow data to be stored or retrieved from a selected block of memory locations on a "Last in, First out" basis, often described as a LIFO stack.

Condition Code Register (CCR) keeps tally on the result of most instructions by setting to 1 or resetting to 0 certain bits. Thus if the last result yielded a negative result, the "N" bit would be set to 1. Branch instructions must "look" at the CCR before deciding whether or not to branch.

There may also be a special bit called the "Carry" which is set if the last arithmetic instruction resulted in a carry. Overflow bits and Interrupt mask bits may also be allocated positions in the CCR. An alternative name for this register is the Program Status Register.
Figure 4 may give some idea of the data paths expected in a "typical" chip.

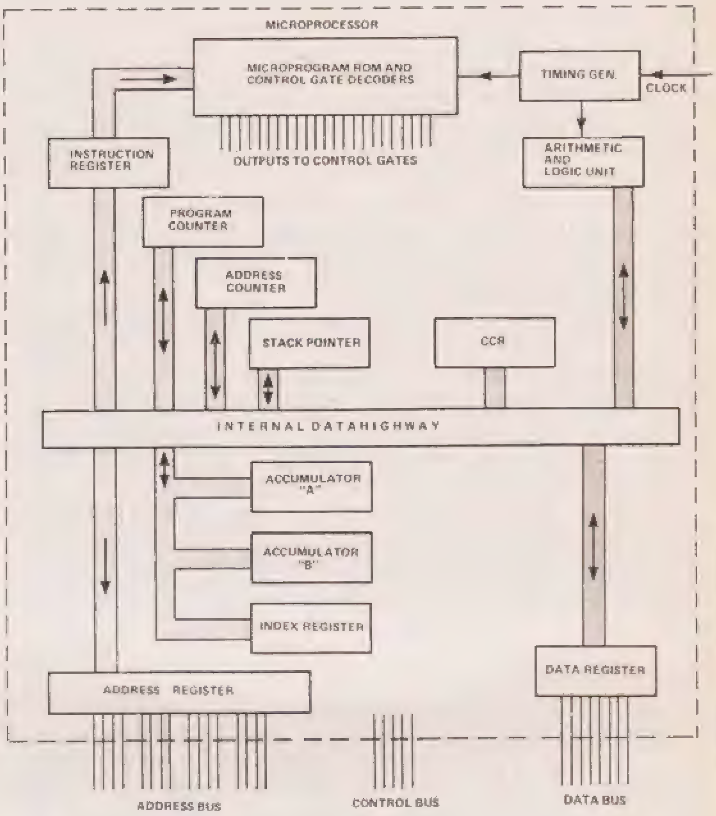


Figure 4. Pathways for the data to roam!

Communication between the various registers is via the internal data highway, each register having an input gate and an output gate. The individual steps of an instruction microprogram are triggered off by timing pulses which "read" the ROM. The pulses are normally subdivisions of the clock pulse, produced by the timing pulse generator. The word read out from the ROM is virtually an input to a decoding matrix which selects the appropriate pair of gates and/or timing pulses. As mentioned previously, the OP code received, by reading the external ROM holding the program, is brought into the instruction register, where it functions as the starting address of the microprogram associated with that OP code. As far as the overall picture is concerned, the action can be broken down into:

a. FETCH PHASE
The next instruction is brought out from external ROM and routed internally via the data bus and highway. The Program Counter is then incremented.

b. EXECUTE PHASE
The instruction is executed.

Thus the action is a repetative FETCH, EXECUTE, FETCH, EXECUTE ad infinitum until the program is halted.

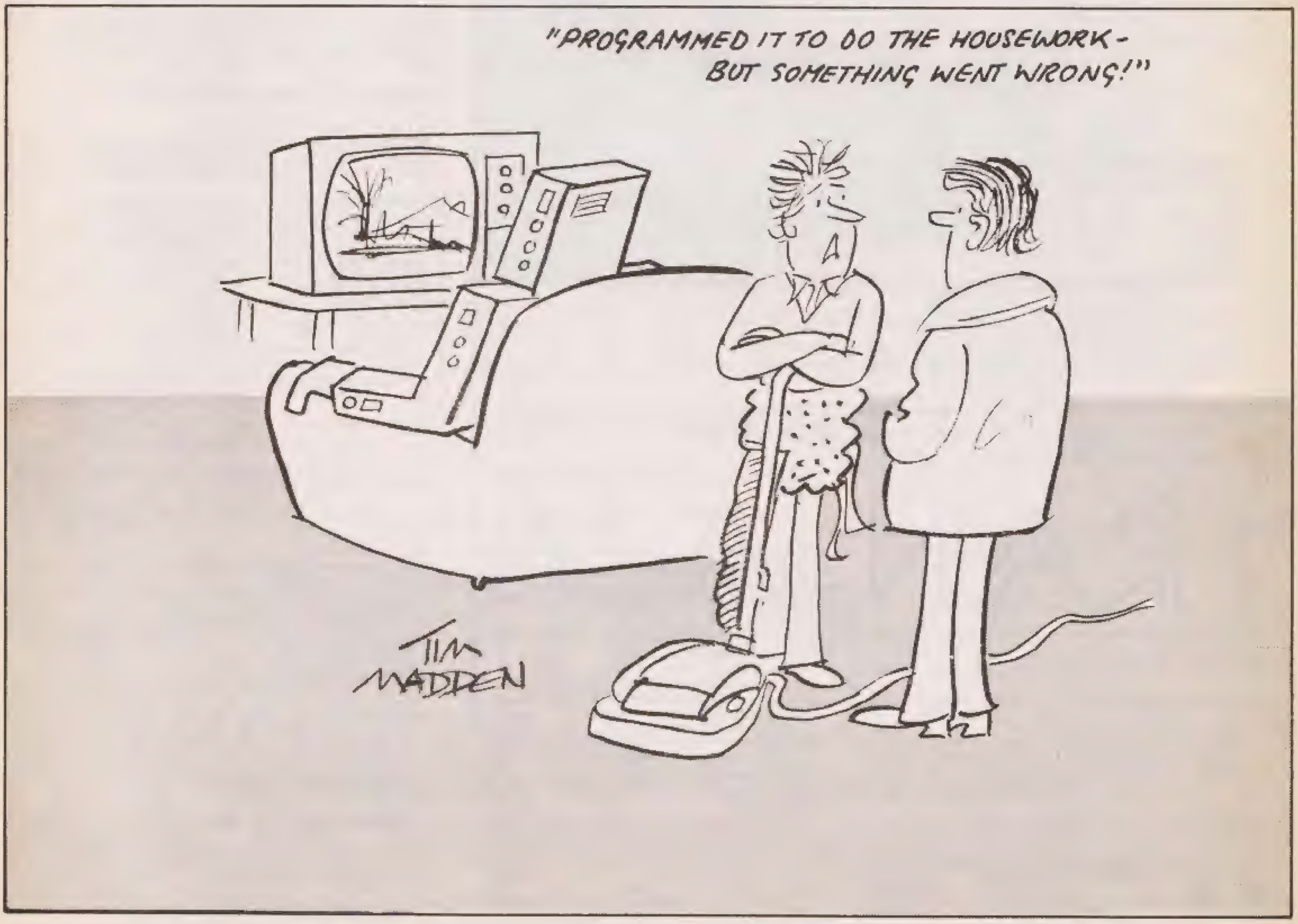
With the short word length of microprocessors, the situation is a little awkward because the average instruction cannot be "Fetched" in one go. In fact, many instructions are three-bytes in length: one byte for the OP code and two bytes for the operand which means that the Program Counter must be incremented three times to fetch such instructions. During the Execute phase, the same problem can exist because the operand is normally an address which necessitates a further couple of trips to external RAM. Thus it can be seen that some instructions can gobble up three or four clock pulses. If the "average" instruction takes n pulses, then the average execution time of an instruction is clearly equal to Clock frequency/n, a disappointing drop in apparent performance! The advantage of choosing Inherent addressing mode should now be clear———no operand. Because some rather disparaging comments were made earlier regarding the doubtful advantage of the 16 bit microprocessor, it would be ethical at this point to highlight the speed advantage during the Fetch phase. Thus the complete instruction, code and operand, can often be fetched in one clock pulse because of the longer word length.

Microprocessor Or Hardwired?

In the present euphoric atmosphere surrounding microprocessors it is easy to become infatuated with them and to cultivate a condescending air towards systems employing hardwired logic (gates, counters flipflops etc.) If a system is to be designed, the first question should not be "which microprocessor" but rather "is a microprocessor necessary at all"? In fact it may be considered strange that such a fundamental question should be left until the last paragraph of these notes. But, until some idea of the complexity surrounding the things have been discussed there would be no solid ground to make such decisions. Even with knowledge, it is not easy although the following can be taken as rough guidelines:

a. HARDWIRED
If a system is not too complex, if very high speed is essential, if subsequent modification is not envisaged and development time is at a premium, then the hardwired solution is probably the better solution.

b. MICROPROCESSOR
If the system demands the opposite to the above then use a microprocessor. Also if one is used, extra sophistication which would have been useful but rejected on grounds of cost if hardwired, can be introduced at little extra cost.



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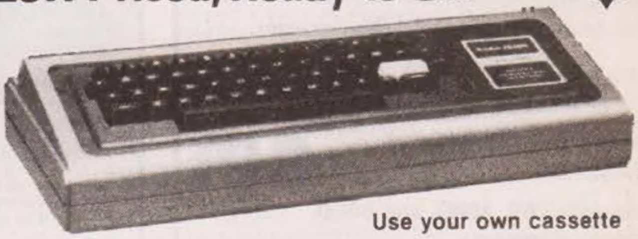

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